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ROJA MUTHIAH
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VARADACHARY & CO.
BOOKSELLERS & PUBLISHERS,
8 LINGHI CHETTY ST., MADRAS-1

# SYSTEMATIC ANATOMY

## ANGIOLOGY : NEUROLOGY
## ORGANS OF SENSES &
## SURFACE ANATOMY

MUSTAFI'S

# SYSTEMATIC ANATOMY

VOLUME THIRD

ANGIOLOGY : NEUROLOGY : ORGANS OF SENSES : SURFACE ANATOMY

EDITED BY

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ROJA MUTHIAH
47, HOSPITAL STREET
KOTTAIYUR-623 106
P. M. DIST-INDIA

NEW EDITION

WITH NUMEROUS COLOURED ILLUSTRATIONS

PUBLISHED BY S. K. MUSTAFI,
9, SANKHARITOLA LANE,
CALCUTTA
1932

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Printed by S. K. Banerjee B.A., at the COTTON PRESS,
57, Harrison Road, Calcutta.

COLOUR AND HALFTONE BLOCKS BY LAKSHMIBILAS COLOUR STUDIO
14, JAGANNATH DUTTA LANE, CALCUTTA.

## PREFACE TO THE NEW EDITION

In response to a demand from the students and owing to a considerable increase of size by the incorporation of Embryology it has been necessary to publish the book in four volumes. Volume I.: Osteology and Syndesmology. Volume II.: Myology and Splanchnology. Volume III.: Angiology, Neurology, Organs of Senses, and Surface Anatomy. Volume IV.: Embryology.

NANI LAL PAN

Medical College, Calcutta,
June, 1932.

# PREFACE

In presenting this treatise my one aim has been to give in as clear and simple a manner as practicable a description in complete detail of the structures composing the human body. The text has been profusely illustrated, the diagrams being so made as to be thoroughly instructive and conveying a clear conception of the details given in the text.

The B.N.A. terminology has been used throughout the book but it has been thought desirable to retain the old names also in parentheses.

I feel confident that the book will establish its claims to usefulness and serviceability to those for whom it is intended.

NANI LAL PAN

Medical College, Calcutta
June, 1927.

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# THE VASCULAR SYSTEM—ANGIOLOGY

The vascular system consists of (1) the heart, (2) the arteries, (3) the veins, and (4) the lymphatic vessels and lymph glands.

The heart is a hollow muscular organ which is divided into two receiving and two propelling chambers. The receiving chambers are called atria to which blood flows from veins and as soon as the atria are full they contract to pour their contents into the two propelling chambers called the ventricles. The ventricles now contract and propel the blood into the arteries.

The series of tubes which convey blood from the heart to the tissues is known as the arteries : of these the pulmonary artery conveys venous blood to the lungs for oxygenation and all the other arteries convey oxygenated blood to the tissues. The arteries divide and subdivide and ultimately minute branches called *arterioles* are formed. These arterioles end in networks of very minute vessels called *capillaries.* In the liver the minute blood vessels differ in structure from the capillaries and are known as *sinusoids.* Arteries unite with one another, so also their branches. These unions, known as *anastomoses,* establish *collateral circulation* and are of great importance when an arterial trunk requires to be ligatured. Each artery is provided with three coats. (1) The *tunica externa* consists mainly of white connective tissue ; in all except the smallest arteries numerous elastic fibres are also present. (2) The *tunica media* consists chiefly of unstriped muscular tissue. (3) The *tunica interna* consists of an endothelial lining and a layer of fine connective tissue fibres. The arterial walls are supplied with numerous small arteries called *vasa vasorum* which are distributed to the outer and middle coats. The arterial walls are supplied also with nerves which are seen in each of the three coats.

The right half of the heart contains venous or impure blood which is conveyed by the pulmonary arteries to the lungs where it becomes arterialised and is then returned to the left half of heart. The arterial or pure blood is then driven into the aorta. The aorta and its various branches convey the arterial blood to all parts of the body, except the lungs. Thereafter it is returned as venous blood to the right half of the heart. There are thus two circulations : one in the lungs called the *pulmonary,* and the other in the whole body called the *systemic.* Then again the blood from the abdominal portion of the alimentary canal (except the anal canal) and from the spleen, pancreas and gall bladder passes through the portal vein to the liver and then through the hepatic veins to the inferior vena cava to reach the general circulation—the passage of blood by this route constitutes the *portal* circulation. From the three circulations, the pulmonary, the systemic and the portal, three systems of blood vessels are seen in the human body viz. (1) the pulmonary system, (2) the systemic system, and (3) the portal system. The pulmonary artery and pulmonary veins belong to the first group. The aorta is the main systemic artery and from its trunk all the systemic arteries are derived. The veins of the portal system carry the blood to the liver by the portal vein which divides like an artery and ultimately ends in sinusoids. From the sinusoids the radicles of the hepatic veins are formed from which the blood is poured into the inferior vena cava and thus into the general systemic circulation.

## THE HEART

The **heart** is a hollow muscular organ which receives and propels blood.

**Position.**—The heart lies obliquely in the middle mediastinum between the two lungs inside the pericardium (Fig. 205). It projects more into the left side than into the right, about one third of the organ lying to the right, and about two thirds of it to the left of the medial plane.

**Shape and size.**—The heart has the shape of an irregular cone. A normal heart measures 5 inches in length from base to apex, 3½ inches at its broadest part, and 2½ inches in thickness. Its average weight is a little more than 10 ounces in the male and about 9 ounces in the female.

**Component parts.**—There are grooves on the outer surface of the heart which indicate the internal subdivision of the organ into four cavities. Thus a transverse groove, called the *coronary sulcus* (auriculoventricular groove) runs transversely showing the line of separation of the upper two chambers called the atria from the lower two chambers called the ventricles. The groove is deficient in front being crossed by the root of the pulmonary artery. Another groove, the *interatrial groove* (interauricular groove), which runs vertically upwards from the preceding groove on the posterior aspect of the atrial portion of the heart, shows the line of separation between the right and left atria. A vertical groove, called the *anterior longitudinal sulcus* (anterior interventricular groove), passes over the sternocostal surface of the ventricular portion of the heart near its left border. It ends below at the inferior border of the heart close to the apex, where a notch is seen immediately to the right of the apex, called the *incisura apicis cordis.* This sulcus shows the line of subdivision of the ventricular portion into a right and a left ventricle anteriorly. Another vertical groove, called the *posterior longitudinal sulcus* (posterior interventricular groove), extends from the coronary sulcus to the incisura apicis cordis on the diaphragmatic surface of the ventricles close to the right border of the heart. This sulcus indicates the line of separation between the right and left ventricles posteriorly.

**General description.**—The heart presents for examination a base, an apex, two surfaces, and three borders (Figs. 206, 207). The *base* is the attached end of the organ and is formed chiefly by the left atrium and by a small portion of the right atrium. It is directed upwards, backwards and to the right and is placed opposite the fifth to eighth thoracic vertebræ inclusive. It is in relation above with the bifurcation of the pulmonary artery and is bounded below by the coronary sulcus, on the right by the sulcus terminalis, and on the left by the oblique vein of the left atrium and the ligament of the left vena cava. The *apex* is somewhat rounded and is formed entirely by the left ventricle. It is directed downwards, forwards and to the left and lies against the left fifth intercostal space $3\frac{1}{2}$ inches to the left of the midsternal line. The *sternocostal surface* is convex and is formed chiefly by the right atrium and the right ventricle and to a small extent by the left atrium and left ventricle. On it are seen the coronary sulcus and the anterior longitudinal sulcus. This surface is placed behind the body of the sternum and the cartilages of the third to sixth ribs inclusive. It is overlapped by the pleuræ and the anterior margins of the lungs except at the region of the cardiac notch of the left lung. The *diaphragmatic surface* is flattened and is formed chiefly by the left ventricle and to a small extent by the right ventricle. It lies mostly on the central tendon and on a small portion of the left muscular part of the diaphragm and on it are seen the posterior part of the coronary sulcus and the posterior longitudinal sulcus. The *right border* is almost vertical and placed behind the third, fourth and fifth costal cartilages; it is rounded and formed by the right atrium. The *left border* is thick and rounded and formed chiefly by the left ventricle and to a small extent by the left auricula. It extends from a point in the second left intercostal space about one inch from the margin of the sternum obliquely dowanwards to the apex of the heart. The *inferior border* is almost horizontal and extends from the apex of the heart to the sternal end of the sixth right costal cartilage. It is thin and formed by the right ventricle.

**Arteries.**—The coronary arteries supply the heart with blood for its nutrition, and are two in number, a right and a left. These will be described in the Section on Arteries.

**Veins.**—The veins return the blood from the substance of the heart. These will be described in the Section on Veins.

**Nerves.**—The nerve supply of the heart is derived from the coronary plexuses which are two in number, a right (anterior) and a left (posterior). The *right coronary plexus* accompanies the right coronary artery and is derived from the superficial cardiac plexus and also from the deep cardiac plexus. The *left coronary plexus* accompanies the left coronary artery and is derived from the deep cardiac plexus only. Minute ganglia are found in these plexuses. Filaments from these plexuses terminate in the muscle fibres of the heart.

**Chambers of the heart.**—The heart consists of four chambers, viz., right and left atria, and right and left ventricles.

The **right atrium** (right auricle) consists of two parts, the sinus venarum and the auricula. The sinus venarum is the main chamber and is situated between the superior and inferior venæ cavæ. The auricula (auricular appendix) is the ear-shaped projection which is directed forwards and to the left overlapping the root of the aorta. A groove, seen on the outer surface of the atrium and called the *sulcus terminalis*, extends from the front of the superior vena cava to the front of the inferior vena cava and indicates externally the line of separation between the sinus venarum and the auricula. In the interior of the atrium this separation is indicated by a vertical ridge called the crista terminalis which corresponds in position to the sulcus terminalis. The capacity of the right atrium is less than three ounces.

The interior of the right atrium (Fig. 208) presents the following parts for examination :—(1) The orifices of (*a*) the superior vena cava, (*b*) the inferior vena cava, (*c*) the coronary sinus, and (*d*) the anterior and smallest cardiac veins ; (2) the right atrioventricular orifice, (3) the valves of (*a*) the inferior vena cava, and (*b*) the coronary sinus ; (4) the fossa ovalis, (5) the limbus fossa ovalis, (6) the musculi pectinati and the crista terminalis, and (7) the intervenous tubercle.

The *orifice of the superior vena cava* is situated at the upper and back part of the right atrium and is directed towards the right atrioventricular opening. It is not guarded by any valve. The

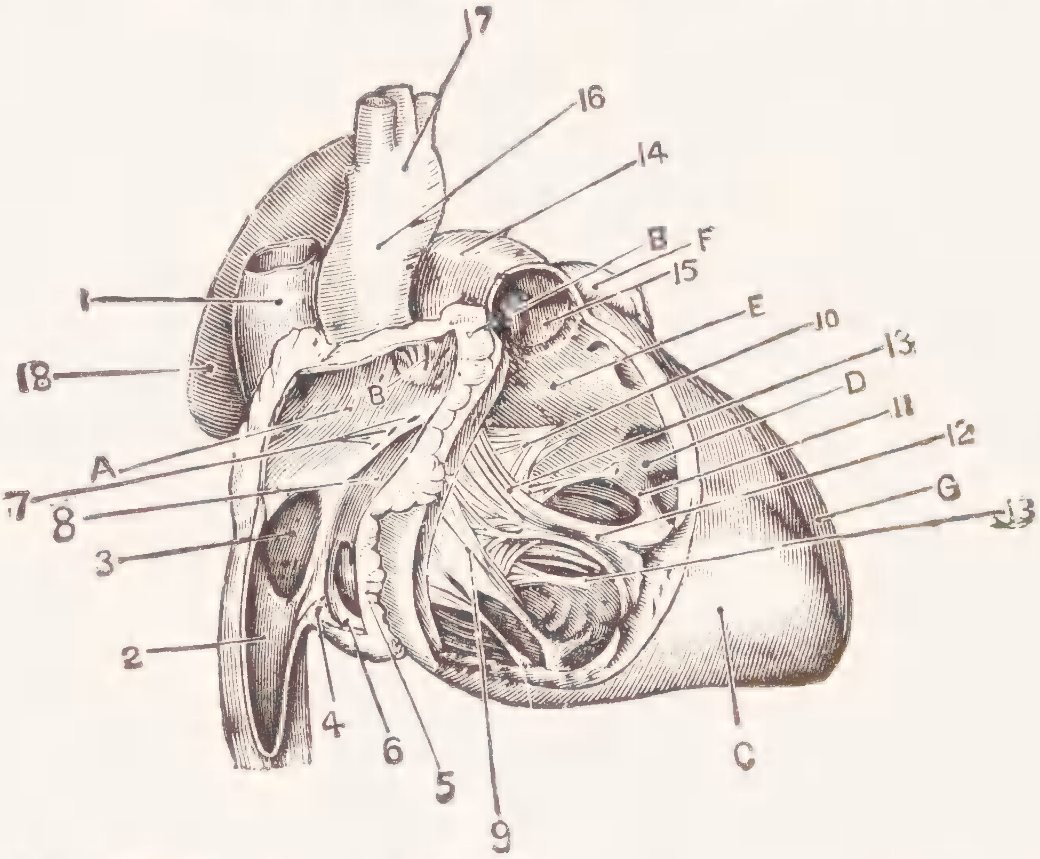

Fig. 208.—The interior of the right atrium and right ventricle.

A. Cavity of right atrium.
B. Auricula.
B. Musculi pectinati.
C. Right ventricle.
D. Cavity of right ventricle.
E. Conus arteriosus.
F. Apex of left auricula.
G. Left ventricle.
1. Superior vena cava.
2. Inferior vena cava.
3. Fossa ovalis.
4. Valve of the inferior vena cava.
5. Opening of the coronary sinus.
6. Coronary valve.
7. Orifices of venæ cordis minimæ.
8. Commencement of auriculoventricular opening.
9. Tricuspid valve.
10. Medial cusp.
11. Trabeculæ carneæ.
12. One of the musculi papillares.
13. Chordæ tendineæ.
14. Pulmonary artery.
15. Semilunar valves.
16. Ascending aorta.
17. Arch of the aorta.
18. Descending aorta.

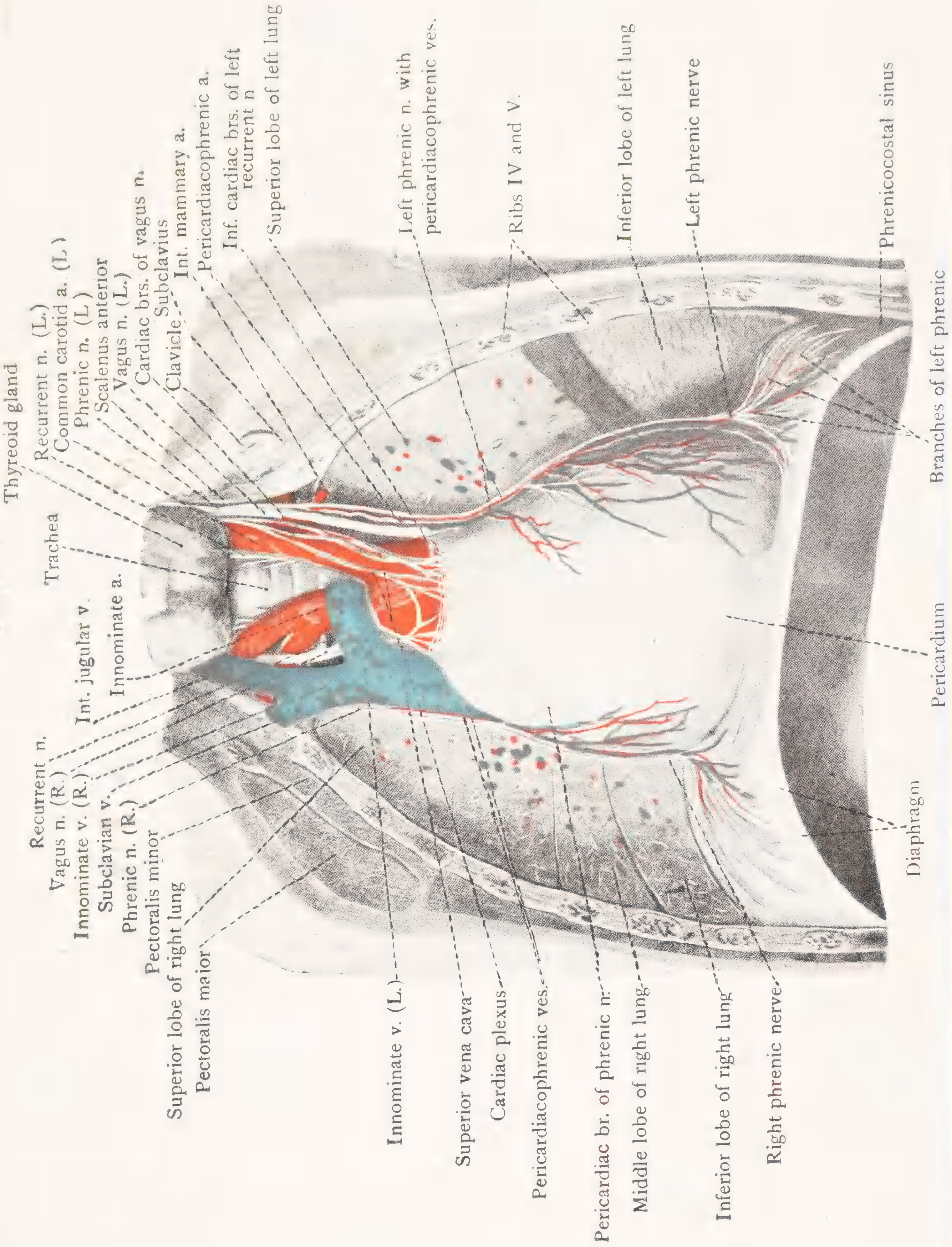

Fig. 205,—The pericardium and the great vessels of the heart.

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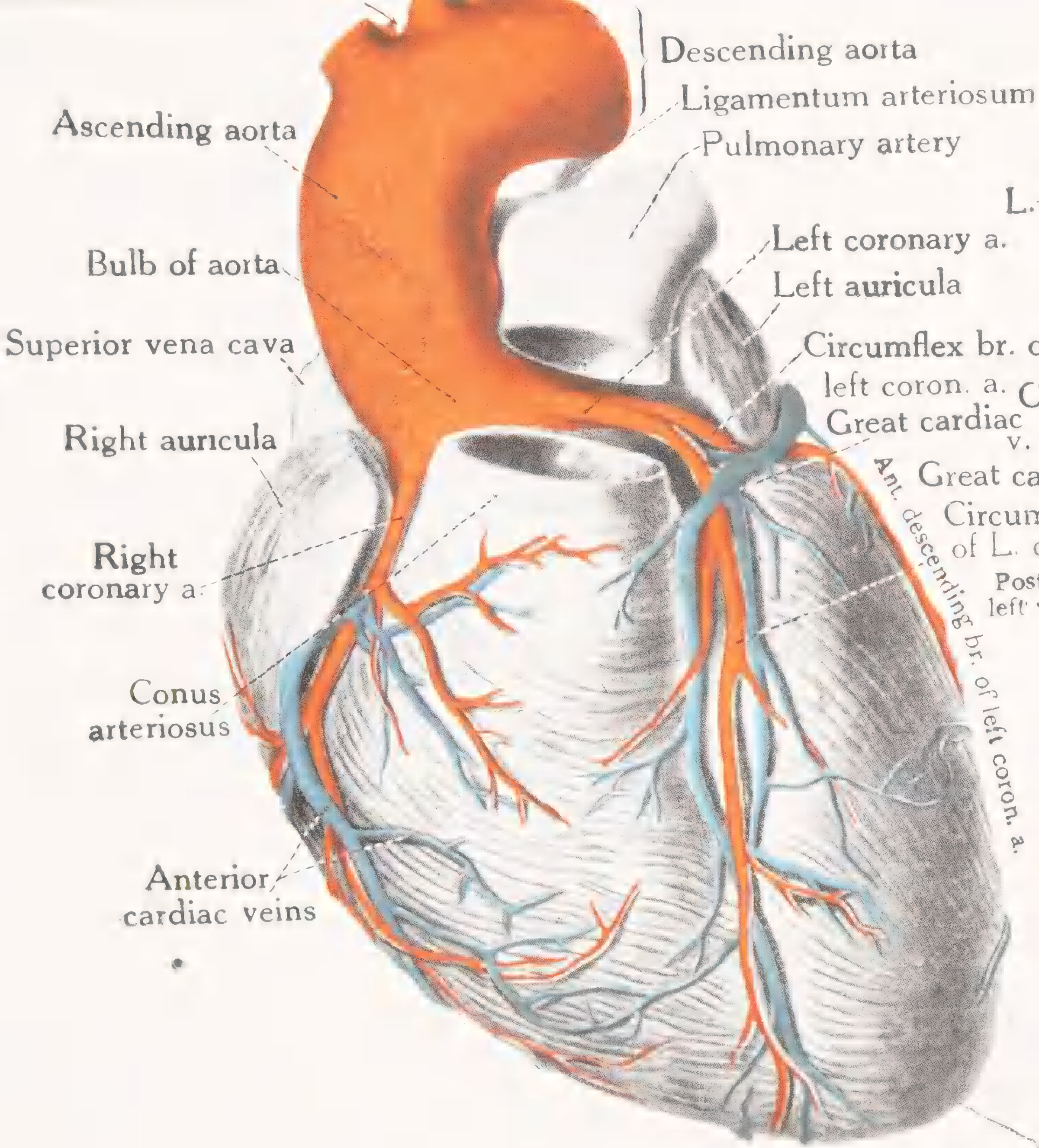


Fig. 206.—The sternocostal surface of the heart.

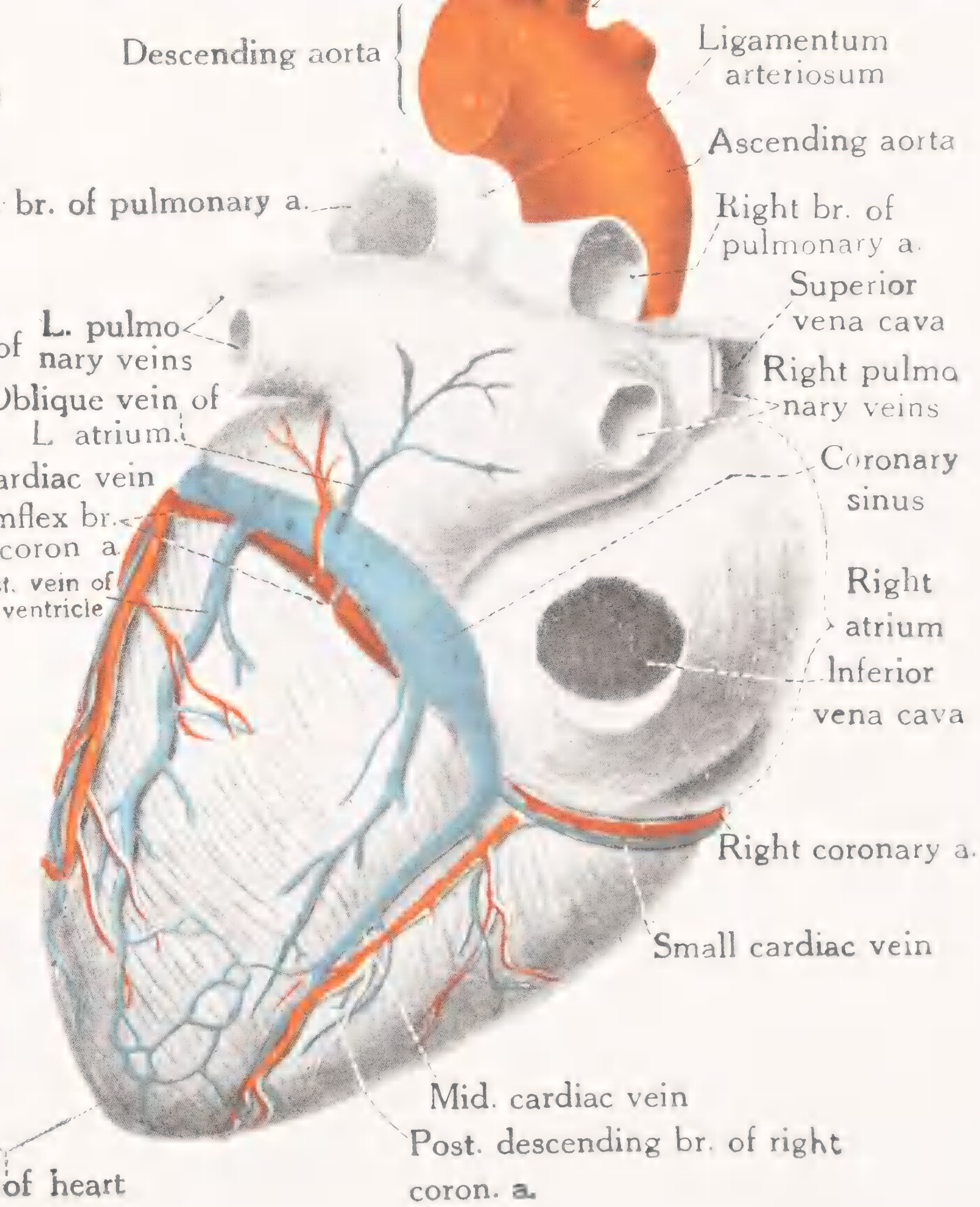


Fig. 207.—The base and the diaphragmatic surface of the heart.

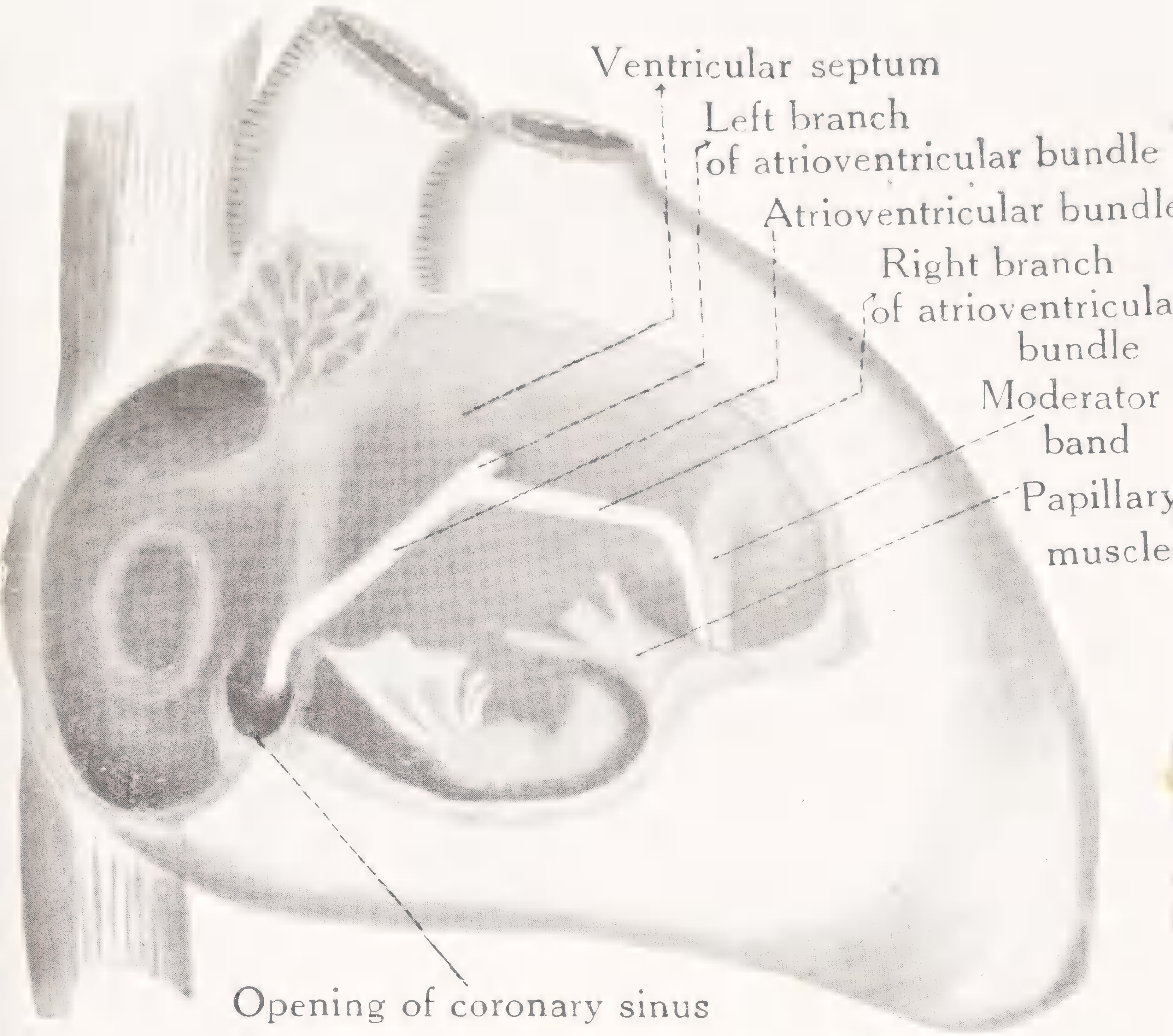


Fig. 211.—The atrioventricular bundle.

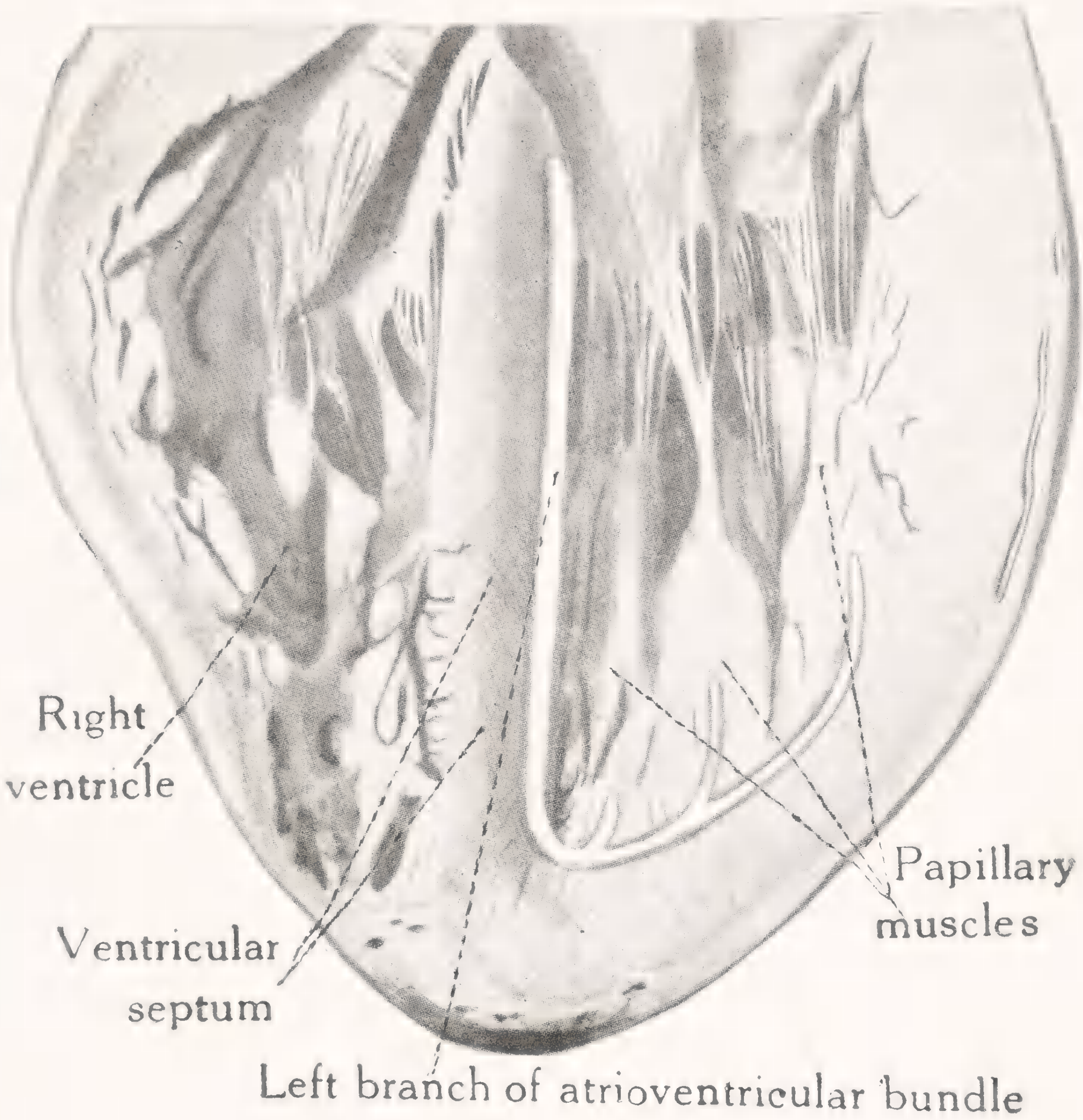


Fig. 212.—View of the left branch of the atrioventricular bundle.

To face p. 365.

*orifice of the inferior vena cava* is placed at the lower part of the right atrium and is directed towards the atrial septum. It is guarded by a valve. The *orifice of the coronary sinus* is situated between the opening of the inferior vena cava and the right atrioventricular opening. It is guarded by a valve. The *orifices of the anterior cardiac veins* and *of the smallest cardiac veins* (venæ cordis minimæ) are minute openings scattered over the internal surface of the atrium. The *right atrioventricular orifice* is the opening by which the right atrium communicates with the right ventricle. It admits the tips of three fingers and is guarded by the tricuspid valve.

The *valve of the inferior vena cava* (Eustachian valve) is semilunar in shape ; it is formed by a duplicature of the lining membrane of the heart, called the endocardium, and contains a little muscular tissue. Its convex margin is attached to the margin of the orifice. Its concave margin is free, the left end of which is attached to the ridge in the atrial septum, called the limbus fossa ovalis, and the right end is lost on the wall of the atrium. This valve may be cribriform or altogether absent in the adult but is a large structure in the fœtus.

The *valve of the coronary sinus* (Thebesian valve) is a crescentic fold of endocardium guarding the opening of the coronary sinus. Sometimes it is double or is cribriform.

The right atrium is separated from the left atrium by a septum called the *atrial septum.* Upon this partition, above the opening of the inferior vena cava is seen an oval depression, called the *fossa ovalis*, which is bounded above and at the sides by a raised margin. This fossa is the remains of the *foramen ovale* of the fœtus through which the blood passed before birth from the right into the left atrium. The *limbus fossa ovalis* (annulus ovalis) is the prominent margin which bounds the fossa ovalis ; it is prominent above and at the sides but deficient below.

The *musculi pectinati* are muscular elevations, so named from their resemblance to the teeth of a comb. These are seen in the auricula and in the adjacent anterior wall of the atrium. They terminate in a common vertical ridge, called the *crista terminalis,* which is smooth and muscular.

The *intervenous tubercle* (tubercle of Lower) is a small elevation on the posterior wall of the atrium below the orifice of the superior vena cava. It is prominent in the hearts of quadrupeds but in man is seldom seen. It directs the current of blood from the superior vena cava into the right atrioventricular orifice.

The following points are to be noted :—(1) the wall of the right atrium is thin ; (2) the whole of its interior has a shining appearance ; (3) the internal surface of the right atrium is smooth behind the crista terminalis but in front of the crista it presents a contrast owing to the musculi pectinati.

The right atrium receives the venous blood returned chiefly by the superior and inferior venæ cavæ. The blood then flows into the right ventricle through the right atrioventricular opening.

**Right ventricle.**—Its *antero-superior surface* forms the greater part of the sternocostal surface of the heart. Its *inferior surface* forms a small portion of the diaphragmatic surface of the heart and rests upon the central tendon of the diaphragm. Its *posterior wall* is formed by the septum which separates it from the left ventricle, called the *ventricular septum* ; this septum bulges into the the cavity of the right ventricle and so on a cross section the cavity would appear semilunar in shape. Its *base* is directed upwards and to the right. At its upper and left part is a conical pouch, called the *conus arteriosus*, which leads to the orifice of the pulmonary artery. The conus arteriosus is connected by its posterior surface to the aorta by a fibrous band called the *tendon of the conus arteriosus.* The *apex* of the right ventricle looks downwards towards the apex of the heart. The cavity of the right ventricle is triangular in form and semilunar on transverse section. Its capacity is about 3 ounces. The following parts are seen in the interior of the right ventricle (Fig. 208) :—(1) right atrioventricular orifice, (2) pulmonary orifice, (3) tricuspid valve, (4) pulmonary semilunar valves, (5) trabeculæ carneæ, and (6) chordæ tendineæ.

The *right atrioventricular orifice* allows the passage of blood from the right atrium into the right ventricle. It is an oval aperture situated at the base of the ventricle, behind the sternum and on a level with the fourth intercostal space. It measures about 1 inch in diameter being slightly larger than the left atrioventricular orifice and admits the tips of three fingers. It is surrounded by a fibrous ring to which is attached the tricuspid valve. The *pulmonary orifice* is situated at the summit of the conus arteriosus and allows the passage of blood from the right ventricle into the lungs through the pulmonary artery. It is situated opposite the upper border of the third costal cartilage of the left side near its junction with the sternum. It is guarded by the pulmonary semilunar valves which are attached to a fibrous ring surrounding the pulmonary orifice.

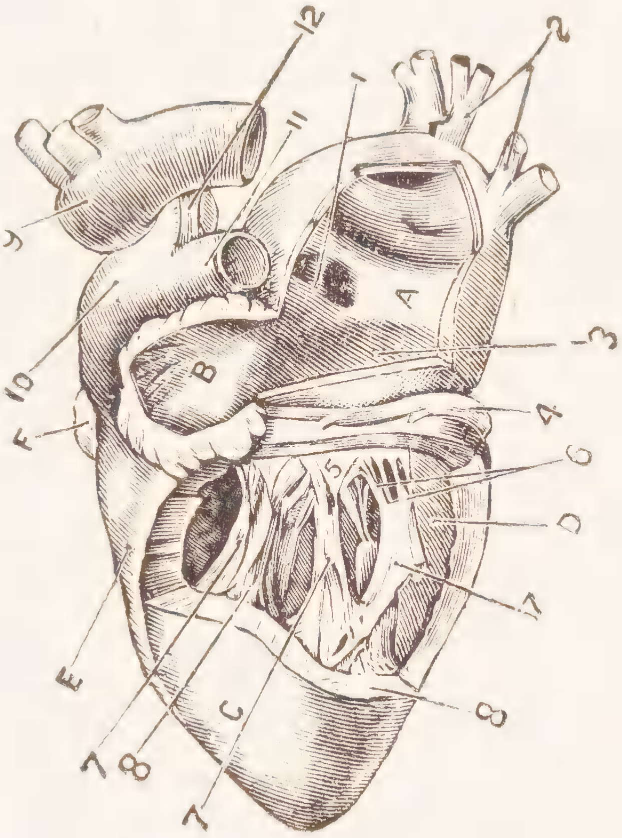
The *tricuspid valve* is formed by three triangular segments or cusps, which prevent regurgitation of the blood into the right atrium during the contraction of the right ventricle. Like all the valves of the heart, it is formed by a duplicature of the lining membrane, the endocardium, within which is contained a very thin layer of fibrous tissue. The three segments or cusps (anterior, posterior, and medial) are united by their bases and are fixed to a fibrous ring surrounding the atrioventricular orifice while their apices hang down into the ventricular cavity. The chordæ tendineæ are attached to the apices, adjacent margins and ventricular surfaces of the cusps. The central part of each cusp is rather thick while the marginal part is thin ; the atrial surface is smooth while the ventricular surface is rough. The *anterior cusp* is situated between the atrial opening and the conus arteriosus ; the *posterior cusp* lies against the wall of the ventricle near the inferior margin of the heart ; and the *medial cusp* (septal cusp) lies against the ventricular septum.

The *pulmonary semilunar valves* are three in number, of which two are placed anteriorly and one posteriorly. They are attached by their convex margins to the orifice of the pulmonary artery, while their concave margins are free and directed upwards and present in the centre of each a thickened nodule, the *nodulus of the valve* (corpus Arantii). The fibrous tissue is spread out in each cusp between the two layers of the endocardium throughout its whole extent except along two narrow semilunar areas, one on either side of the central nodule. These semilunar areas of the cusps are called the *lunulæ* which are very thin and consist only of two layers of endocardium. Between the cusps and the wall of the pulmonary artery are three pouches (sinuses of Valsalva).

The inner surface of the right ventricle is smooth in the region of the conus arteriosus but its remaining part presents numerous muscular projections of various length and thickness. These muscular bands are called *trabeculae carneæ* (columnæ carneæ) and are of three kinds. The first set forms *ridges* on the ventricular wall being attached to it by their whole length. The second set forms *bridges* being attached to the ventricular wall by their two extremities, the intermediate portion being free. One fleshy band of this group, called the *moderator band*, is seen to be attached by one extremity to the ventricular septum and by the other to the base of the anterior papillary muscle. It prevents over-distension of the ventricle. The third set, called the *musculi papillares* is of considerable size being fixed at one end to the ventricular wall while the other end gives attachment to several fine tendinous cords, the *chordae tendineæ* which keep the valve in place. The papillary muscles are usually two in number. The *anterior papillary muscle* is the larger and is attached by its base to the anterior wall of the ventricle ; from its apex the chordæ tendineæ pass to the anterior and posterior cusps of the tricuspid valve. The *posterior papillary muscle* is fixed by its base to the ventricular septum and the chordæ tendineæ pass from its apex to the posterior and medial cusps of the tricuspid valve. Sometimes the posterior muscle is represented by three or four smaller projections. Some chordæ tendineæ arise directly from the ventricular septum and pass to the anterior and medial cusps.

The **left atrium** is smaller than the right but its walls are a little thicker. It is concealed by the aorta and the pulmonary artery. Like the right atrium it consists of a main cavity and an auricula. The latter is longer and more curved than the auricula of the right atrium and projects to the right overlapping the root of the pulmonary artery. The interior of the left atrium (Fig. 209) presents for examination : (1) the orifices of the four pulmonary veins, (2) the left atrioventricular orifice, (3) the orifices of the venæ cordis minimæ, and (4) musculi pectinati.

The *orifices of the four pulmonary veins* are seen on the posterior wall of the atrium. These orifices are not guarded by valves. Oxygenated blood from the lungs is brought into the left atrium by the pulmonary veins. The two left pulmonary veins often open by a common orifice. The *left atrioventicular orifice* is placed in the anteroinferior part of the atrium. It is smaller than the right atrioventricular orifice and admits the tips of two fingers. It is guarded by the bicuspid or mitral valve. The *orifices of the venae cordis minimae* are fewer than those in the right atrium.



A. Cavity of the left atrium.
B. Cavity of the auricula in which are seen the musculi pectinati.
C. Left ventricle.
D. Cavity of the left ventricle.
E. Right ventricle.
F. Apex of the right auricula.
1. Opening of the two right pulmonary veins.
2. Left pulmonary veins.
3. Auriculo-ventricular opening.
4. Coronary sinus.
5. Mitral valve.
6. Chordæ tendineæ.
7. Musculi papillares.
8. Trabeculæ carneæ.
9. Aortic arch.
10. Pulmonary artery.
11. Left pulmonary artery.
12. Ligamentum arteriosum.

Fig. 209.—The interior of the left atrium and left ventricle.

The *musculi pectinati* are smaller and fewer than those in the right atrium and are limited to the auricula only.

The right atrium is separated from the left by a fibromuscular partition called the *atrial septum* ; on it a small depression is sometimes seen bounded below by a semilunar ridge. This depression corresponds to the fossa ovalis seen on the other side of the septum.

The **left ventricle** is conical in shape ; its cavity is oval or circular on transverse section ; its walls are three times as thick as those of the right ventricle. It forms a small part of the sternocostal and the greater part of the diaphragmatic surface of the heart ; it also forms the whole of the apex of the heart. The following parts are seen in the interior of the left ventricle (Fig. 209) :—(1) The left atrioventricular opening and (2) mitral valve ; (3) the aortic opening and (4) aortic semilunar valves ; (5) the trabeculæ carneæ and (6) chordæ tendineæ.

The *left atrioventricular orifice* lies below and to the left of the aortic orifice. It is situated behind the left margin of the sternum on a level with the fourth left costal cartilage. It is surrounded by a fibrous ring to which the mitral valve is attached.

The *mitral* or *bicuspid valve* is similar in structure to the tricuspid valve but consists of two cusps which are larger and thicker than those of the tricuspid valve. The *anterior* or *aortic cusp* is larger than the posterior and lies in front and to the right of the atrioventricular orifice. The *posterior cusp* lies behind and to the left of the atrioventricular opening. The free margins of the cusps and their ventricular surfaces give attachment to the chordæ tendineæ which are thicker and stronger than those of the tricuspid valve.

The *aortic orifice* is situated in front and to the right of the left atrioventricular orifice. It is guarded by the aortic semilunar valves. The portion of the ventricular cavity just below the aortic orifice is called the *aortic vestibule* and is destitute of muscular tissue.

The *aortic semilunar valves* (Fig. 210) are three in number of which two are posterior (right and left) and one anterior. They are larger and thicker than the pulmonary semilunar valves. The nodules at the free margins of the valves are more prominent and the lunulæ are more distinctly seen. The pouches between the cusps and the wall of the aorta, called the *aortic sinuses* (sinuses of Valsalva), are larger than those of the pulmonary artery; moreover the orifices of the coronary arteries are seen

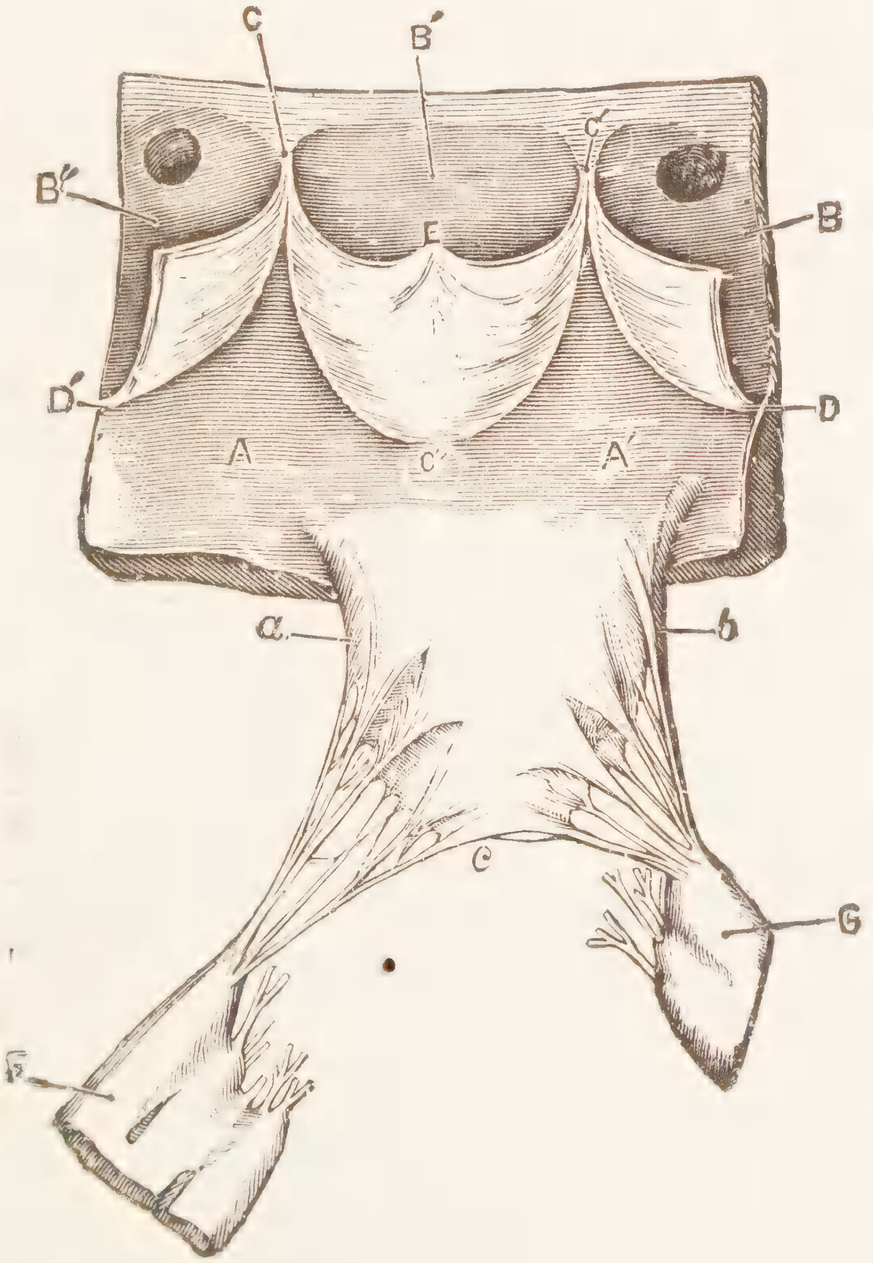


Fig. 210.—Diagram to illustrate the attachments of one cusp of the mitral valve and the aortic valves.

A, A′. Portion of the ventricular wall and B. B′. B″. aorta.

B. B′. B″. Sinuses of aorta; in B and B″ openings of coronary arteries are seen.

C. C′. } Attached
D. D′. } border of semilunar valve.

E. Nodule of the valve seen in the middle of the free border of the valve. The lunulæ are seen on either side of E.

F. G. Musculi papillares.

*a*. *b*. *c*. Attachment of the chordæ tendineæ.

in these sinuses. The right coronary artery arises from the anterior aortic sinus while the left from the left posterior sinus.

The *trabeculæ carneæ* are of three kinds as in the right ventricle but they are more numerous and form a very dense network upon the posterior wall of the ventricle and at the apex but on the septum and anterior wall they are not prominent. The *musculi papillares* are thicker and stronger than those in the right ventricle. They are two in number; one is attached to the anterior wall and the other to the posterior wall of the ventricle. They give attachment to the chordæ tendineæ by their free rounded extremities. The chordæ tendineæ from each papillary muscle are attached to the margins and ventricular surfaces of both cusps of the mitral valve.

A fibromuscular partition is placed between the right and left ventricles called the *ventricular septum.* The greater portion of the septum is thick and muscular and is called the *muscular ventricular septum* but its upper and posterior portion is thin and membranous and consists only of fibrous tissue covered by endocardium and is called the *membranous ventricular septum*; it constitutes a part of the wall of the aortic vestibule. The lower portion of the septum is specially thick near the apex of the heart. The anterior margin of the septum is attached opposite the anterior longitudinal sulcus and the posterior margin opposite the posterior longitudinal sulcus. The septum bulges into the right ventricle, hence the cavity of the right ventricle is semilunar on section and that of the left ventricle is circular.

**Structure of the heart.**—The external surface of the heart is covered by the visceral layer of the serous pericardium, called the *epicardium.* Its cavities are lined by a smooth membrane called the *endocardium* which is continuous with the inner coat of the blood vessels entering and leaving the organ. Between these two membranes is the *myocardium* or the muscular wall of the heart. In addition to these structures there exist four fibrous rings surrounding the four orifices viz., the two atrioventricular and two arterial orifices (the aortic and the pulmonary). The *atrioventricular rings* are interposed between the muscle fibres of the atria and the ventricles and give attachment to those muscular fibres as also to the tricuspid and mitral valves. The *aortic* and *pulmonary rings* are interposed between the muscle fibres of the ventricles and the muscular coats of the arteries; the semilunar valves are attached to them. The muscular tissue of the heart includes (1) the fibres of the atria, (2) the fibres of the ventricles, and (3) the atrioventricular bundle.

The *fibres of the atria* are distinct from those of the ventricles. They are arranged in two layers, a superficial and a deep. The superficial layer runs transversely encircling both the atria. The deep layer runs anteroposteriorly from the atrioventricular rings and is limited to each atrium. This layer is arranged circularly around the auricula, the fossa ovalis and the openings of the veins.

The *fibres of the ventricles* are also arranged in two layers, a superficial and a deep. The superficial fibres common to both cavities begin at the atrioventricular rings and pass obliquely donwards to the apex. Fibres passing from the right atrioventricular ring pass downwards and to the left across the anterior longitudinal sulcus to the apex of the left ventricle while those from the left atrioventricular ring pass across the diaphragmatic surface of the heart downwards and to the right to the apex of the right ventricle. Reaching the apices of the two ventricles they are coiled and form two vortices, one at each apex. Then they pass upwards along the inner aspect of the walls of the ventricles to the bases of the papillary muscles of their respective ventricles. The deep fibres are arranged in ∽—shaped manner and connect the papillary muscles of one ventricle with those of the other by dipping at the longitudinal sulcus.

The **atrioventricular bundle** (Figs. 211, 212) is a bundle of muscle fibres which connects together the muscle fibres of the atria and ventricles and thus establishes direct muscular continuity between them for the propagation of the wave of contraction. It consists of two collections of spindle-shaped cells, called nodes, from which fibres take their origin and form into a bundle. The upper node is called the *sinoatrial node* and is situated near the opening of the superior vena cava at the upper end of the sulcus terminalis. From this the fibres proceed beneath the endocardium to the lower node, called the *atrioventricular node,* which is situated a little below the opening of the coronary sinus. From this node the bundle proceeds as an undivided bundle towards the lower part of the pars membranacea septi and at the upper part of the muscular portion of the ventricular septum breaks into two branches, a right and a left. The right branch runs along the right side of the septum and along the moderator band to the anterior papillary muscle of the right ventricle. The left branch runs along the left side of the septum and ends at the base of the papillary muscle. Both divisions give off numerous offsets which are blended with the muscular fibres of the ventricles.

The **pericardium** (Fig. 205) is a conical fibroserous bag containing the heart and the roots of the great vessels. *In front* of it is the anterior mediastinum. It is partly covered in front by the anterior margins of the lungs and the pleuræ. *Behind* it, is the posterior mediastinum with its contents. *Laterally* it lies in contact with the mediastinal pleuræ, and the phrenic nerve with the pericardiacophrenic artery runs down between the pericardium and pleura on either side. Its *base* is attached mainly to the central tendon of the diaphragm. Its *apex* is prolonged over the great vessels connected with the base of the heart.

**Structure.**—The pericardium consists of two layers, an external fibrous and an internal serous layer. The *fibrous layer* is attached below to the central tendon of the diaphragm encroaching upon its left muscular part. *Above* it is prolonged on the great vessels forming tubular sheaths for them (except for the inferior vena cava) and is continuous with the pretracheal layer of the fascia colli. In front it is attached to the sternum by two fibrous bands called the *superior* and *inferior sternopericardial ligaments*. The superior band passes to the back part of the manubrium and the inferior band to the back part of the xiphoid process. The *serous layer* forms a shut sac. It is divisible into two portions, a parietal and a visceral. The *parietal portion* lines the inner surface of the fibrous layer and is reflected over the heart to form the visceral portion or *epicardium.* The great vessels connected with the heart receive coverings from the visceral portion to the extent of about an inch and a half. The ascending aorta and the pulmonary artery are enclosed in a single complete sheath of the visceral layer called the *arterial mesocardium,* while the two venæ cavæ and the four pulmonary veins are enclosed in a separate sheath of the visceral layer called the *venous mesocardium* which is arranged in the form of an inverted **U**. The space behind the arterial mesocardium is called the *transverse sinus of the pericardium* ; the pouch of the venous mesocardium between the two limbs of the inverted **U** is called the *oblique sinus of the pericardium.*

Between the left pulmonary artery and the left upper pulmonary vein there exists a triangular fold of the serous layer. This is known as the *ligament of the left vena cava* (vestigeal fold of Marshall). It contains the fibrous remains of the lower part of the left superior vena cava of the embryo.

*Arterial supply.*—The fibrous layer and the parietal portion of the serous layer are supplied by (1) the pericardial and musculophrenic branches of the internal mammary artery, and (2) the pericardial branches of the descending thoracic aorta ; the visceral portion of the serous layer is supplied by twigs of the coronary arteries.

*Nerve-supply.*—The pericardium is by supplied the vagus, and phrenic nerves and sympathetic trunks.

## THE ARTERIES

### The Pulmonary Artery

The **pulmonary artery** (Figs. 206, 207) is a short vessel, about two inches in length, and conveys venous blood from the right ventricle to the lungs. It arises from the summit of the conus arteriosus and passes upwards and backwards at first in front of and then to the left side of the ascending aorta. It then divides under cover of the arch of the aorta opposite the fibrocartilage between the fifth and sixth thoracic vertebræ into a right and a left pulmonary artery. The serous layer of the pericardium encloses this vessel and the ascending aorta in a common tubular sheath. The right auricula and the right coronary artery lie to the right side of the vessel, while the left auricula and the left coronary artery lie to its left side. The superficial cardiac plexus lies between the bifurcation of the pulmonary artery and the arch of the aorta.

The **right pulmonary artery** is longer and larger than the left. It passes lateralwards to the right behind the ascending aorta and the superior vena cava to the hilum of the right lung forming one of the constituents of its root. It divides into an upper and a lower branch. The upper is the smaller branch and passes in company with the eparterial bronchus and is distributed to the upper lobe of the right lung ; the lower one is the larger branch and is distributed to the middle and lower lobes.

The **left pulmonary artery** passes lateralwards to the left in front of the descending aorta and the left bronchus to the hilum of the left lung, forming one of the constituents of its root. It divides into two branches, an upper and a lower, which are distributed to the upper and lower lobes of the left lung. The root of the left pulmonary artery is connected to the under surface of the left part of the aortic arch by a short fibrous cord called the *ligamentum arteriosum.* It is the remains of a vessel, called the ductus arteriosus, which during fœtal life conveys blood from the pulmonary artery to the aorta.

## The Aorta

The **aorta** is the great arterial trunk from which all the arteries of the body derive oxygenated blood. It begins at the aortic orifice of the left ventricle and ascends obliquely to the right behind the sternum as far as the second right costal cartilage. This portion is called the *ascending aorta.* Then it arches backwards and to the left and reaches the lower border of the body of the fourth thoracic vertebra on its left side forming the *arch of the aorta.* From here it runs downwards along the vertebral column under the name of the *descending aorta* through the thorax and abdomen and terminates on the left of the median plane at the level of the fourth lumbar vertebra by dividing into the right and left common iliac arteries. The portion of the descending aorta contained within the thoracic cavity is called the *thoracic aorta ;* the portion within the abdominal cavity, the *abdominal aorta.*

The **ascending aorta** (Figs. 206, 207) springs from the base of the left ventricle on a level with the lower border of the third left costal cartilage posterior to the left margin of the sternum. From its origin it ascends upwards and to the right describing a slight curve and terminates in the arch of aorta at the level of the second right costal cartilage posterior to the right margin of the sternum. It is about two inches in length and is enclosed by the serous layer of the pericardium in a tubular sheath common to it and the pulmonary artery. It presents three small dilatations at its commencement called the *aortic sinuses.* There is a fourth dilatation where it terminates in the arch of the aorta and is called the *bulb of the aorta* or the *great sinus of the aorta.* Its commencement is *covered* by the pulmonary artery and higher up it is overlapped by the anterior margin of the right lung and right pleura. The right atrium and the superior vena cava lie on its *right side.* The pulmonary artery lies on its *left side* at a higher level. *Posteriorly* it is in relation with the left atrium and the right pulmonary artery.

The *branches* of the ascending aorta are the right and left coronary arteries (Figs. 206, 207).

The **right coronary artery** arises from the anterior aortic sinus. It passes forwards between the root of the pulmonary artery and the right auricula. It then turns to the right along the coronary sulcus, winds round the right margin of the heart and passes towards the left along the coronary sulcus on the diaphragmatic surface of the heart. Reaching the upper end of the posterior longitudinal sulcus it divides into a small transverse branch and a posterior descending branch. The *transverse branch* continues the course of the main artery along the coronary sulcus and anastomoses with the circumflex branch of the left coronary artery. The *posterior descending branch* descends along the posterior longitudinal sulcus towards the apex of the heart. While at the right margin of the heart the right coronary artery gives off a *marginal branch* which runs along the inferior border of the heart towards the apex and supplies branches to both surfaces of the right ventricle.

The **left coronary artery** is larger than the right and arises from the left posterior aortic sinus. It passes to the left behind the pulmonary artery and then between the pulmonary artery and the left auricula and divides into two branches. One of these, the *circumflex branch,* runs to the left along the coronary sulcus, curves round the left margin of the heart to the diaphragmatic surface of the organ and anastomoses with the transverse branch of the right coronary artery ; while the other, the *anterior descending branch,* runs downwards along the anterior longitudinal sulcus to the apex of the heart anastomosing with the posterior descending branch of the right coronary artery.

The **arch of the aorta** (Figs. 206, 207) lies in the superior mediastinum behind the manubrium sterni and connects the ascending with the descending aorta. It commences posterior to the right margin of the sternum at the level of the second right costal cartilage and terminates to the left of the lower border of the fourth thoracic vertebra where it becomes the descending aorta. At first it passes upwards, backwards and to the left in front of the trachea ; then it passes backwards along the left side of the trachea ; finally it passes downwards along the left side of the fourth thoracic vertebra. *In front* it is covered by the pleuræ and lungs. It is crossed vertically along its left part by the left vagus and left phrenic nerves, the inferior cervical cardiac branch of the left vagus and the superior cervical cardiac branch of the left sympathetic nerve and the left superior intercostal vein. *Behind* it are the trachea, the œsophagus, the thoracic duct, the left recurrent nerve and the deep cardiac plexus. *Above* it is in relation with the left innominate vein and gives origin to the innominate, left common carotid and left subclavian arteries. *Below*, in the concavity of the arch are the superficial cardiac plexus, the left recurrent nerve, the bifurcation of the pulmonary artery, the left bronchus, and the ligamentum arteriosum.

**Branches.**—These are (1) the innominate, (2) the left common carotid, and (3) the left subclavian.

The **innominate artery** (Fig. 205) is the largest branch of the arch of the aorta. It ascends obliquely to the right and divides behind the upper border of the right sternoclavicular articulation into the right common carotid and the right subclavian arteries. *In front* it has the manubrium sterni, the origins of the sternohyoid and sternothyreoid muscles, the left innominate vein and the remains of the thymus gland. *Behind* it, is the trachea which is crossed by it obliquely. On its *right side* are the right pleura, the right innominate vein with the right vagus nerve behind it, the superior vena cava, and the right phrenic nerve. On its *left side* are the left common carotid artery below and the trachea above.

*Branches.*—Usually no branch is given off from the innominate artery but occasionally a small artery, the *thyreoidea ima,* arises from it and passes in front of the trachea to supply the thyreoid gland.

## THE ARTERIES OF THE HEAD AND NECK

The two common carotid trunks are the main arteries of the head and neck; other arteries, e.g. the vertebral arteries, are distributed to the head and neck but these will be described with the arteries of their own region. Each common carotid artery divides into (1) the external carotid artery which supplies the structures of the head and neck situated externally; (2) the internal carotid artery which supplies the structures in the cranial and orbital cavities.

The **common carotid artery** (Fig. 213) begins on the right side behind the right sternoclavicular articulation at the bifurcation of the innominate artery, while on the left side it springs from the arch of the aorta. On each side the vessel terminates on a level with the upper border of the thyreoid cartilage by dividing into the external and internal carotid arteries. The left artery has therefore an additional intrathoracic portion.

The **left common carotid artery** arises from the arch of the aorta to the left of and posterior to the innominate artery. It consists of a thoracic portion and a cervical portion. The **thoracic portion of the left common carotid artery** extends from the arch of aorta to the left sternoclavicular articulation. *In front* of it are the sternum, the origins of the left sternohyoid and sternothyreoid muscles, the left innominate vein and the remains of the thymus gland. *Behind*, it has at first the trachea, and higher up, the œsophagus, the left recurrent nerve and the thoracic duct. To its *right side* is the innominate artery below and the trachea higher up. To its *left side* are the left pleura and the left vagus nerve.

The **common carotid arteries in the neck.**—The right common carotid artery and the cervical portion of the left common carotid artery resemble each other closely in their relations. At the lower part of the neck the common carotid arteries are deeply placed and are separated from each other by the trachea and œsophagus. At the upper part of the neck they are more superficial and are separated from each other by the thyreoid cartilage and the pharynx. Each artery is contained in the cartoid sheath. The structures lying *in front* of the vessel are:—the skin, superficial fascia, platysma, fascia colli and the sternocleidomastoideus (throughout the entire length of the vessel); the descending branch of the hypoglossal nerve and the branches from the ansa hypoglossi descend in front of the sheath of the vessel; the sternohyoid and sternothyreoid muscles lie in front of it (at its lower part), the omohyoid muscle passes over it opposite the cricoid cartilage; the sternocleidomastoid branch of the superior thyreoid artery, the superior and middle thyreoid veins cross the vessel from the medial to the lateral side. *Behind* it are the longus colli and capitis, the inferior thyreoid artery, the sympathetic trunk, the recurrent nerve (on the right side) and the thoracic duct on the left side. To its *lateral side* are the internal jugular vein and the vagus nerve; to its *medial side* are the larynx and trachea, the pharynx and the œsophagus, the inferior thyreoid artery, the recurrent nerve and the thyreoid gland. No branches are given off from the common carotid artery.

The **external carotid artery** (Fig. 213) begins opposite the upper border of the thyreoid cartilage at the bifurcation of the common carotid artery and ends in the substance of the parotid gland behind the neck of the mandible by dividing into two branches, the superficial temporal and internal maxillary arteries. At its commencement it lies medial to and more superficial than the internal carotid artery. Here it is contained in the carotid triangle and has *in front* of it the deep fascia and the anterior margin of the sternocleidomastoideus. It is crossed by the lingual and common facial veins and the hypoglossal nerve. Higher up as it enters the posterior part of the submaxillary triangle it is crossed by the digastric and stylohyoid muscles. Still higher up where it enters the substance of the parotid gland it lies beneath the facial nerve and the posterior facial vein. *Behind* the artery there are two muscles, the styloglossus and the stylopharyngeus, and two nerves, the glossopharyngeal and the pharyngeal branch of the vagus nerve. The two nerves separate the external from the internal carotid artery. *Lateral* to it is the internal carotid artery. *Medially* are the pharynx, and the superior laryngeal nerve dividing into its external and internal laryngeal branches, and the posterior border of the ramus of the mandible; medially at a higher level are the pharyngeal branch of the vagus, the stylopharyngeus and the styloglossus, the glossopharyngeal nerve, the styloid process and the stylohyoid ligament—all these structures separate the external from the internal carotid artery.

**Branches.**—The branches of the external carotid artery may be grouped into anterior, posterior and ascending sets.

| *Anterior.* | *Posterior.* | *Ascending.* |
|---|---|---|
| Superior thyreoid. | Occipital. | Ascending pharyngeal. |
| Lingual. | Posterior auricular. | Superficial temporal. |
| External maxillary. | | |
| Internal maxillary. | | |

The **superior thyreoid artery** (Fig. 213) arises just below the greater cornu of the hyoid bone and passes forwards and downwards beneath the omohyoid, sternohyoid and sternothyreoid muscles to end in the thyreoid gland. Medial to it are the inferior constrictor of the pharynx and the external laryngeal branch of the superior laryngeal nerve. It gives off the following **branches**:—(1) The *hyoid branch* passes along the lower border of the hyoid bone beneath the thyreohyoid muscle, supplies the muscle and anastomoses with its fellow of the opposite side. (2) The *sternocleidomastoid artery* passes obliquely downwards and backwards across the carotid sheath to enter the substance of the sternocleidomastoideus. (3) The *superior laryngeal artery* passes in company with the internal laryngeal nerve beneath the thyreohyoid muscle and pierces the hyothyreoid membrane to supply the interior of the larynx where it anastomoses with the inferior laryngeal branch of the inferior thyreoid artery. (4) The *cricothyreoid branch* runs transversely medialwards across the cricothyreoid membrane and anastomoses with the artery of the opposite side. (5) The *glandular branches* are the terminal branches which are two or three in number and supply both surfaces of the thyreoid gland; one of these passes along the isthmus of the thyreoid gland to anastomose with its fellow of the opposite side.

The **lingual artery** (Fig. 213) arises above the origin of the superior thyreoid opposite the greater cornu of the hyoid bone. For convenience of description it is divided into four parts. From its origin, the *first part* of the artery ascends and then bending downwards reaches the greater cornu of the hyoid bone forming a loop; it ends at the posterior border of the hyoglossus where the second part begins. The first part is superficial and is contained within the carotid triangle; it is covered by skin, superficial and deep fasciæ and the platysma and is crossed superficially by the hypoglossal nerve; it rests upon the middle constrictor muscle of the pharynx.The *second part* of the artery runs along the upper border of the greater cornu of the hyoid bone and is placed upon the middle constrictor of the pharynx and under cover of the hyoglossus—the hyoglossus separates the lingual artery from the hypoglossal nerve and vena comitans hypoglossi. The *third part* begins from the anterior border of the hyoglossus and ascends to reach the under surface of the tongue between the genioglossus and hyoglossus muscles. The *fourth part* of the artery is its continuation forwards to the tip of the tongue and is known as the *arteria profunda linguæ* : it is covered only by mucous membrane and is situated below the longitudinalis inferior and lateral to the genioglossus. The **branches** given off from the lingual artery are :—(1) The *hyoid branch* arises in the carotid triangle ; it passes medialwards along the upper border of the hyoid bone, supplies the neighbouring muscles and anastomoses with its fellow of the opposite side. (2) The *rami dorsalis linguæ* are two or three small branches which arise from the second part of the artery and ascend under cover of the hyoglossus to the back part of the dorsum of the tongue to supply its mucous membrane, the palatine tonsil and the soft palate. (3) The *sublingual artery* arises from the second part of the lingual near its termination under cover of the anterior border of the hyoglossus. It passes forwards and upwards upon the genioglossus which it supplies and ends in the sublingual gland. It sends a twig to anastomose with the artery of the opposite side and also with the submental branch of the external maxillary artery. (4) The *arteria profunda linguae* (ranine artery) is the fourth or terminal portion of the lingual artery. It passes to the tip of the tongue with a tortuous course along with the lingual nerve.

The **external maxillary artery** (facial artery) (Figs. 213, 214) arises above the lingual and may be divided into two portions—the first or *cervical portion*, which extends from the origin of the artery to the groove in the mandible at the anteroinferior angle of masseter muscle ; and the second or *facial portion* which winds obliquely upwards and forwards over the face to the medial angle of the eye.

The **cervical portion** of the artery runs upwards and forwards and is at first contained in the carotid triangle ; then it passes under the posterior belly of the digastric and stylohyoid muscles and reaches the submaxillary triangle where it is embedded in the posterior part of the submaxillary gland. Leaving the gland it passes downwards and then upwards to reach the groove in the mandible. The **branches** of the cervical portion are : the ascending palatine, tonsillar, glandular, and submental. The *ascending palatine artery* passes upwards along the lateral wall of the pharynx between the styloglossus and stylopharyngeus ; reaching the apex of the petrous bone it turns downwards and runs along the course of the levator veli palatini ; finally it pierces the pharyngeal aponeurosis and supplies the soft palate. The *tonsillar branch* passes upwards between the styloglossus and the pterygoideus internus and pierces the pharyngeal wall to supply the tonsil and back part of the tongue. The *glandular branches* supply the submaxillary gland. The *submental artery* runs forwards upon the mylohyoid muscle below the lower border of the mandible. Near the symphysis menti it turns upwards over the chin to supply the lower lip and anastomoses with the mental and inferior labial arteries. In its course it supplies the submaxillary lymph glands, the mylohyoid muscle and anastomoses with the sublingual artery by piercing the muscle. It also anastomoses with the mylohyoid branch of the inferior alveolar artery.

The **facial portion** of the external maxillary artery is extremely tortuous in its course. It appears on the face by crossing the body of the mandible at the anteroinferior angle of the masseter muscle. It then runs forwards and upwards to a point a little behind the angle of the mouth. Then it ascends to the medial palpebral commissure and terminates as the angular artery. It rests successively upon the mandible, the buccinator and the caninus. It is covered by the platysma, the risorius, the zygomaticus and the quadratus labii superioris, and is crossed from behind forwards by the branches of the facial nerve. The **branches** of the facial portion may be divided into two sets, a posterior and an anterior. The branches of the posterior set are small branches which pass backwards to supply the masseteric and buccal regions. The branches of the anterior set have distinct names and are named the inferior labial, superior labial, lateral nasal, and angular. The *inferior labial artery* (inferior coronary) arises below the angle of the mouth, passes forwards beneath the triangularis and then along the margin of the lower lip and supplies the muscles and skin of the lower lip. It anastomoses along the middle line with its fellow of the opposite side and with the mental branch of the inferior alveolar artery. The *superior labial artery* (superior coronary artery) arises just above the preceding and passes medialwards along the upper lip between the orbicularis oris and the mucous membrane. It anastomoses with the artery of the opposite side and gives off the *septal artery* which ramifies on the septum of the nose and supplies it as far as the tip of the nose. The *lateral nasal artery* arises from the external maxillary artery when the parent trunk ascends along the side of the nose. It supplies the ala and the dorsum of the nose and anastomoses with its fellow of the opposite side and with the dorsal nasal branch of the ophthalmic artery. The *angular artery* is the terminal portion of the external maxillary artery. It ascends through the angular head of the quadratus labii superioris and terminates at the medial palpebral commissure by anastomosing with the dorsal nasal branch of the ophthalmic artery.

The **occipital artery** (Figs. 213, 214) arises from the back part of the external carotid opposite the origin of the external maxillary artery. It runs upwards and backwards along the lower border of the posterior belly of the digastricus to reach the space between the transverse process of the atlas and the mastoid process of the temporal bone. Its terminal portion is distributed over the posterior part of the scalp. The artery presents three stages in its course. The *first stage* lies anterior to the sternocleidomastoid muscle. Here it crosses the internal carotid artery, internal jugular vein, the vagus and accessory nerves while the hypoglossal nerve hooks round the vessel from behind forwards. The *second stage* of the occipital artery lies under cover of the sternocleidomastoideus; here it is covered by the splenius capitis, longissimus capitis and digastric muscles; it lies at first on the rectus capitis lateralis which separates it from the vertebral artery; it next lies in the occipital groove of the mastoid portion of the temporal bone; it then rests upon the insertion of the obliquus capitis superior. The *third stage* of the occipital artery extends from its emergence from underneath the posterior margin of the sternocleidomastoideus to its termination over the scalp. It enters the interval between splenius capitis and superior nuchal line of occipital bone; here it rests upon the semispinalis capitis and lies under cover of the aponeurosis uniting the occipital attachments of the sternocleidomastoid and trapezius; in company with the greater occipital nerve it pierces the aponeurosis and runs upwards as high as the vertex taking a tortuous course and lying in the superficial fascia of the scalp.

The **branches** of the occipital artery are :—(1) The *sternocleidomastoid branch* passes downwards and backwards and enters the sternocleidomastoid muscle in company with the accessory nerve. (2) The *meningeal branches* accompany the internal jugular vein and pass through the jugular foramen to reach the posterior fossa of the skull where it supplies the duramater. (3) The *auricular branch* is not constant, it runs upwards to supply the concha. (4) The *mastoid branch* is not constant; it passes through the mastoid foramen and supplies the mastoid air sinuses. (5) The *descending branch* (arteria princeps cervicis) arises from the occipital over the superior oblique and passes downwards to the lateral border of the semispinalis capitis where it divides into a superficial and a deep branch. The superficial branch descends between the splenius capitis and semispinalis and supplies these muscles and anastomoses with the ascending branch of the transverse cervical artery. The deep branch descends under cover of the semispinalis capitis to anastomose with the arteria profunda cervicis. (6) The *terminal* or *occipital branches* are two in number, medial and lateral. They ramify over the posterior part of the scalp and anastomose with the corresponding branches of the opposite side and with the superficial temporal arteries.

The **posterior auricular artery** (Fig. 215) arises from the external carotid above the posterior belly of the digastricus. At first it is placed deeply and runs upwards and backwards under cover of the parotid gland, over the styloid process of the temporal bone and reaches the interval between the mastoid process and the cartilage of the external ear where it meets the posterior auricular nerve; it then divides into auricular and occipital branches. It gives off the following *branches* :—(1) *Muscular branches* to the neighbouring muscles. (2) *Glandular branches*

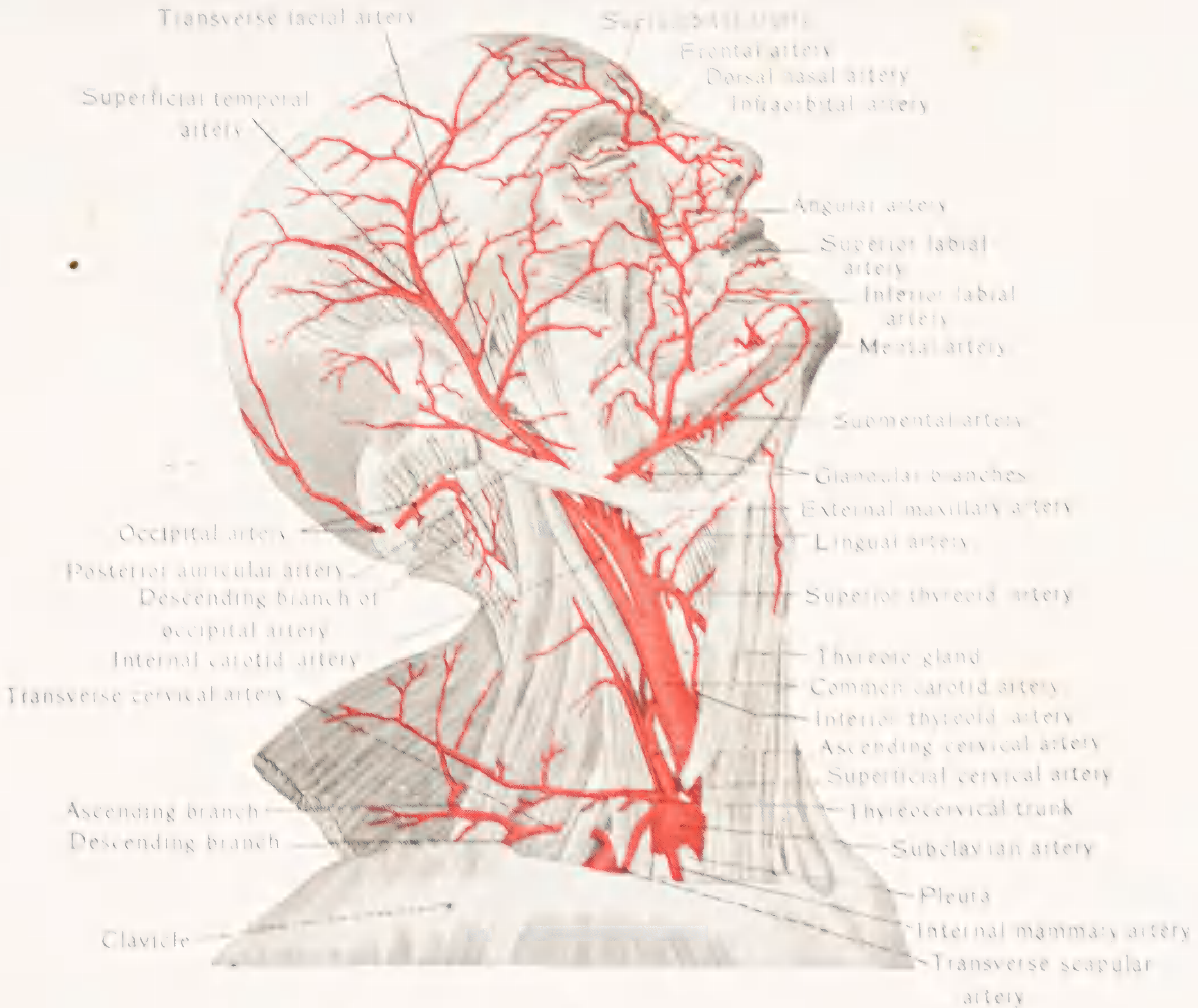


Fig. 141.—Dissection of the neck showing the carotid and subclavian artery.

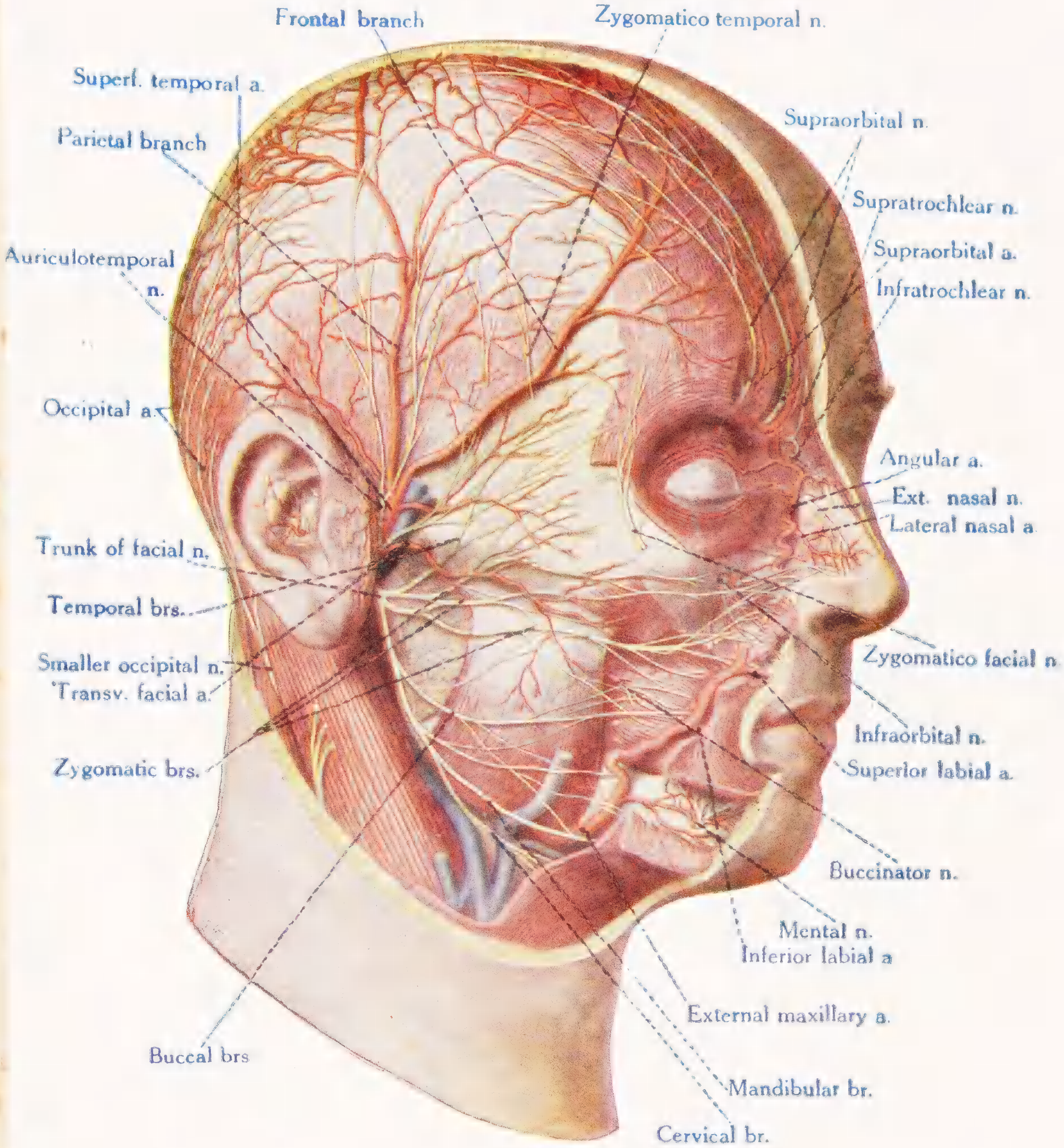


Fig. 214.—The arteries of the scalp and face.

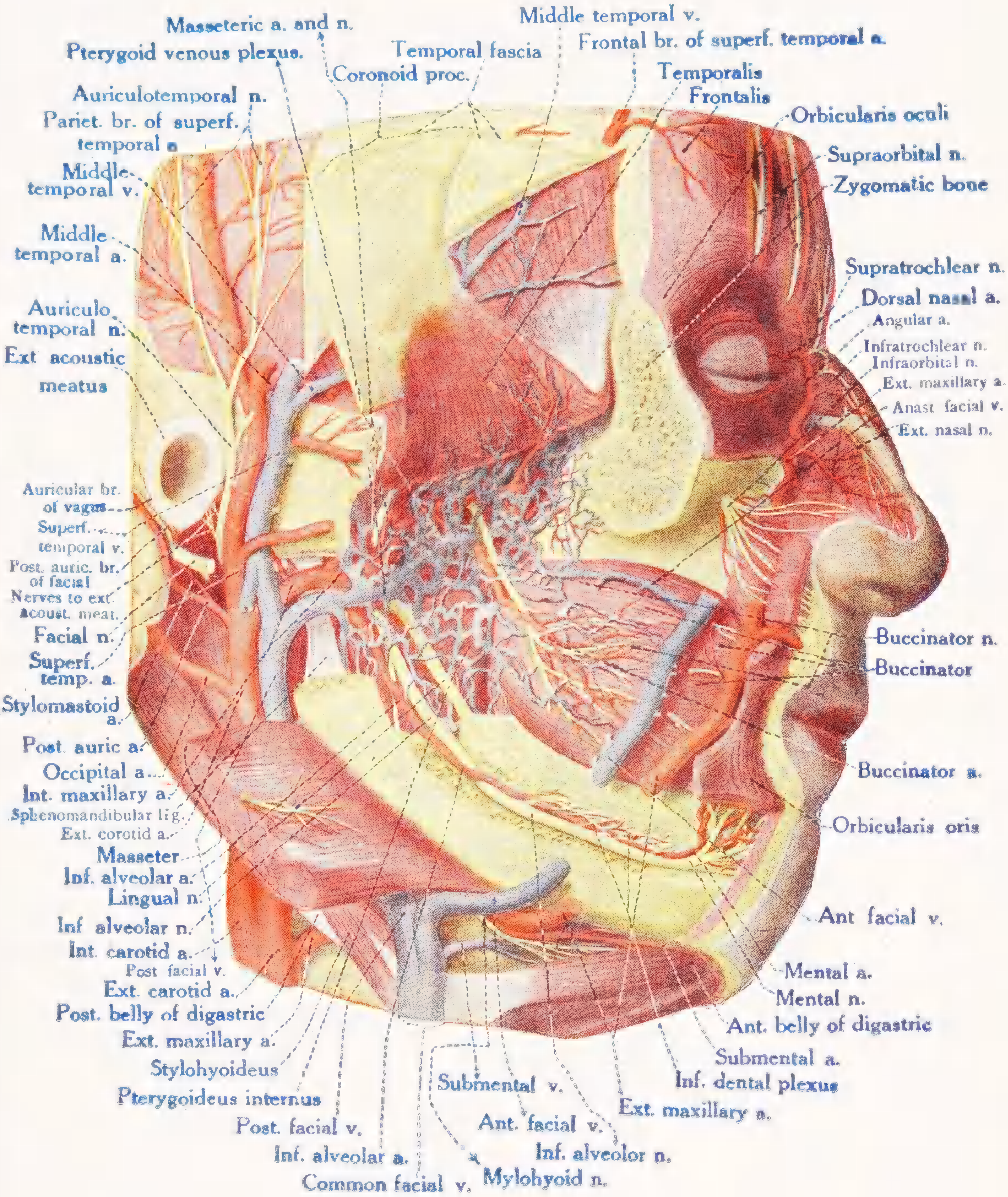


Fig. 215.—The superficial temporal and internal maxillary arteries.

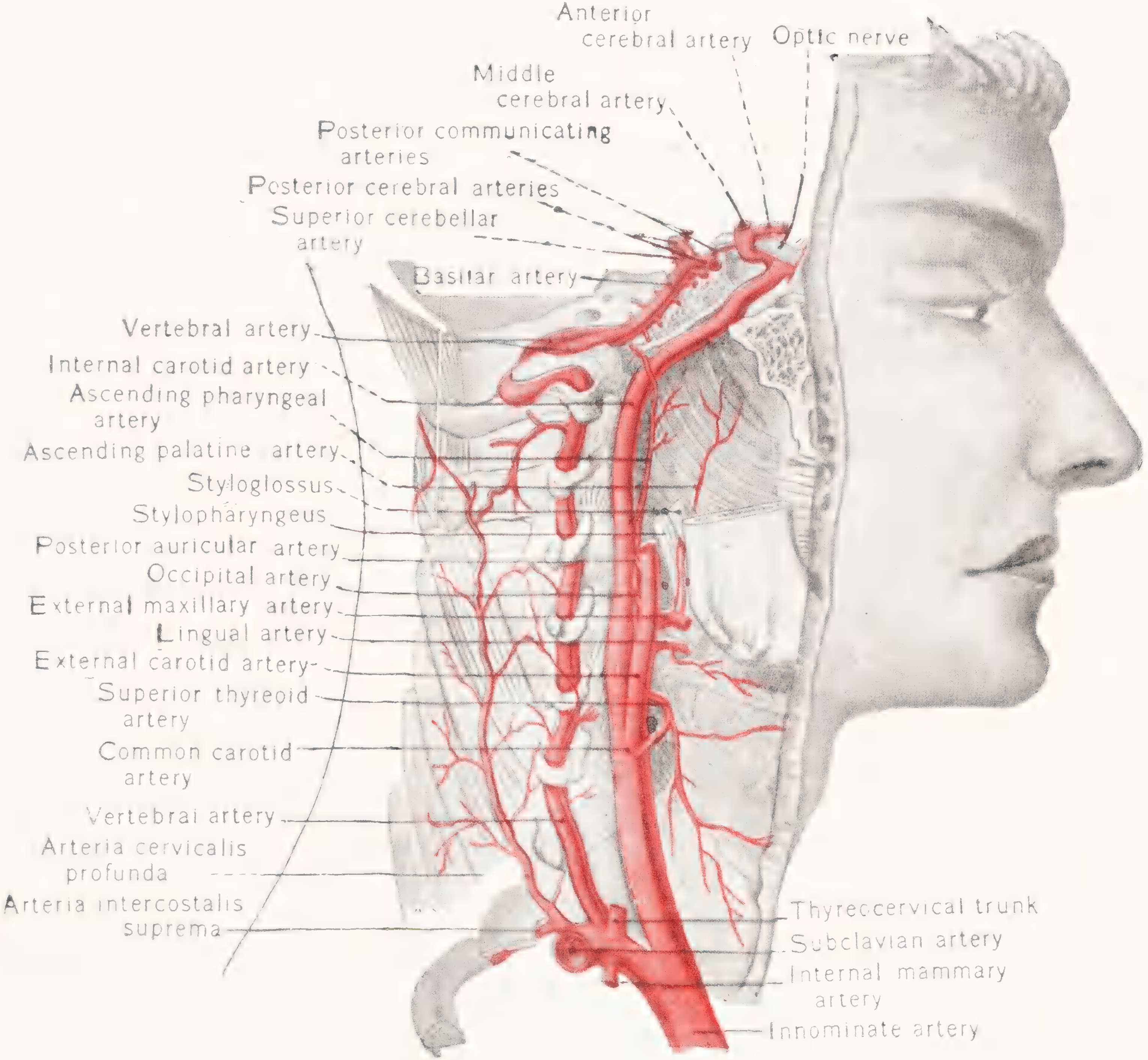


Fig. 216.—The common carotid, external and internal carotid, and vertebral arteries.

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to the parotid gland. (3) The *stylomastoid artery* enters the stylomastoid foramen, supplies the mastoid cells and the tympanic cavity and anastomoses in the facial canal with the petrosal branch of the middle meningeal artery. (4) The *auricular branch* passes upwards beneath the auricularis posterior, supplies the back part of the auricula and anastomoses with the parietal branch of the superficial temporal artery. (5) The *occipital branch* runs backwards and anastomoses with the occipital artery.

The **ascending pharyngeal artery** is a slender vessel which takes origin from the external carotid near its commencement and runs vertically upwards between the internal carotid artery and the wall of the pharynx. Reaching the base of the skull it divides into meningeal branches. It gives off :—(1) *prevertebral branches* which supply the prevertebral muscles and anastomose with the ascending cervical artery ; (2) *pharyngeal branches* which supply the constrictor muscles of the pharynx ; one of these enters the pharynx above the superior constrictor muscle to supply the soft palate and the palatine tonsil ; (3) *meningeal branches* which enter the cranial cavity through apertures at the base of the skull, viz., the jugular foramen, the foramen lacerum and the hypoglossal canal, and supply the dura mater ; (4) *inferior tympanic branch* which enters the tympanic cavity through the inferior tympanic canaliculus in company with the tympanic branch of the glossopharyngeal nerve and anastomoses with the other tympanic arteries.

The **superficial temporal artery** (Fig.215) is one of the terminal branches of the external carotid artery. It begins opposite the neck of the mandible in the substance of the parotid gland and runs upwards between the external acoustic meatus and the condyle of the mandible ; here it is crossed by the temporal and zygomatic branches of the facial nerve. Crossing the posterior root of the zygomatic arch it ascends upon the temporal fascia in company with the auriculotemporal nerve and divides into two terminal branches, the frontal and parietal. **Branches.**—(1) The *parotid branches* are minute twigs which supply the parotid gland. (2) The *articular branches* supply the temporomandibular joint. (3) The *transverse facial artery* arises in the substance of the parotid gland and runs horizontally forwards across the masseter muscle above the parotid duct and below the zygomatic arch. It divides into branches which supply the parotid gland and the masseter and anastomose with the external maxillary, infraorbital, masseteric and buccinator arteries. (4) The *anterior auricular branches* supply the anterior part of the pinna and the lobule of the ear. (5) The *middle temporal artery* arises above the zygomatic arch and piercing the temporal fascia, supplies the temporalis muscle and anastomoses with the deep temporal branches of the internal maxillary artery. (6) The *zygomatico-orbital artery* passes forwards above the zygomatic arch between the two layers of the temporal fascia to the lateral angle of the orbit, supplies the orbicularis oculi and anastomoses with the lacrimal and palpebral branches of the ophthalmic artery. (7) The *frontal branch* passes upwards and forwards supplying the muscles and skin and anastomoses with the supraorbital and frontal arteries. (8) The *parietal branch* curves upwards and backwards along the side of the head and anastomoses with the posterior auricular and occipital arteries and with its fellow of the opposite side.

The **internal maxillary artery** (Fig. 215) is the larger terminal branch of the external carotid artery. It arises behind the neck of the mandible in the substance of the parotid gland and is usually divided into three portions. The *first portion* (mandibular part) proceeds forwards between the neck of the mandible and the sphenomandibular ligament being placed along the lower border of the pterygoideus externus. The *second portion* (pterygoid part) runs obliquely upwards and forwards on the superficial surface of the pterygoideus externus (sometimes on the deep surface of the muscle), being placed under cover of the temporalis muscle. The *third portion* (pterygopalatine part) passes medialwards between the two heads of the pterygoideus externus and enters the pterygopalatine fossa through the pterygomaxillary fissure ; here it lies in front of the sphenopalatine ganglion.

The **branches** of the artery are classified into three sets :—

| From the 1st *part* | From the 2nd *part* | From the 3rd *part* |
|---|---|---|
| 1. Anterior tympanic. | 1. Deep temporal. | 1. Posterior superior alveolar. |
| | 2. Pterygoid. | |
| 2. Deep auricular. | 3. Masseteric. | 2. Infraorbital. |
| 3. Middle meningeal. | 4. Buccinator. | 3. Descending palatine. |
| 4. Accessory meningeal. | | 4. Artery of the pterygoid canal. |
| 5. Inferior alveolar. | | 5. Pharyngeal. |
| | | 6. Sphenopalatine. |

The **anterior tympanic artery** passes upwards behind the mandibular joint and enters the tympanic cavity through the petrotympanic fissure (Glaserian fissure). It supplies the tympanic membrane and anastomoses with the stylomastoid artery on its surface.

The **deep auricular artery** passes upwards through the parotid gland behind the mandibular joint and pierces the anterior wall of the external acoustic meatus to supply the skin lining it.

The **middle meningeal artery** passes upwards along the medial surface of the external pterygoid muscle between the two roots of the auriculotemporal nerve. It enters the cranial cavity through the foramen spinosum. On the great wing of the sphenoidal bone it divides into an anterior and a posterior branch. The *anterior branch*, the larger, passes along the great wing of the sphenoid and ascends along the groove on the inner surface of the sphenoidal angle of the parietal bone and divides into branches between the dura mater and the internal surface of the cranium ; some proceed upwards and supply the dura mater as far as the vertex of the skull; others spread out backwards to the occipital region. The *posterior branch* runs upwards and backwards grooving the squamous part of the temporal bone and the squamous border of the parietal bone and spreads out into branches which supply the posterior part of the dura mater. The *branches* given off from the middle meningeal artery within the cranial cavity are: (1) *ganglionic branches* which supply the semilunar ganglion; (2) *superficial petrosal branch* which enters the hiatus of the facial canal and supplies the facial nerve and the tympanic cavity; (3) *superior tympanic artery* which enters the semicanal for tensor tympani muscle and supplies this muscle; (4) *orbital branch* which enters the orbit through the superior orbital fissure and anastomoses with the lacrimal artery; (5) *temporal branches* which are minute twigs—they leave the cranial cavity through foramina in the great wing of the sphenoid and anastomose in the temporal fossa with the deep temporal arteries.

The **accessory meningeal artery** arises sometimes from the middle meningeal. It enters the cranial cavity through the foramen ovale and supplies the dura mater and the semilunar ganglion.

The **inferior alveolar artery** (inferior dental artery) passes downwards and forwards accompanied by the inferior alveolar nerve and enters the mandibular foramen. It then traverses the mandibular canal with the nerve of the same name and at the level of the mental foramen it terminates by dividing into incisor and mental branches. Before entering the mandibular foramen it gives off two branches: (1) the *lingual branch* which descends with the lingual nerve and supplies the mucous membrane of the mouth; (2) the *mylohyoid artery* which passes downwards and forwards in the mylohyoid groove with the nerve of the same name and ramifies on the superficial surface of the mylohyoid muscle. Within the mandibular canal it gives off *molar, premolar,* and *canine branches* which supply the pulps of these teeth. The *incisor branch* supplies the pulps of incisor teeth. The *mental branch* emerges from the mental foramen and lies under the quadratus labii inferioris and anastomoses with its fellow of the opposite side and with the inferior lateral artery.

The **deep temporal arteries** are two in number, anterior and posterior, which ascend between the pericranium and the temporal muscle. They supply the muscle and also the bones forming the temporal fossa and anastomose with the middle temporal artery.

The **pterygoid branches** are given off to the external and internal pterygoid muscles.

The **masseteric artery** crosses the mandibular notch with the nerve of the same name and enters the deep surface of the masseter muscle.

The **buccinator artery** runs forwards with the buccinator nerve to the outer surface of the buccinator muscle. It supplies the muscle and anastomoses with the branches of the external maxillary artery.

The **posterior superior aveolar artery** (posterior dental artery) descends upon the infratemporal surface of the maxilla and divides into many minute branches ; some of which enter the alveolar canals to supply the lining membrane of the maxillary sinus and the upper molar and premolar teeth ; while others supply the gums.

The **infraorbital artery** passes forwards to the orbit through the inferior orbital fissure. In company with the infraorbital nerve it runs forwards in the infraorbital groove and canal ; reaching the infraorbital foramen, it emerges from that foramen with the nerve on the face and lies beneath the quadratus labii superioris. In the canal it gives off (1) *orbital branches* which supply the structures on the floor of the orbit ; (2) *anterior superior alveolar branches* which descend through the anterior alveolar canals and supply the pulps of the upper incisor and canine teeth and the mucous lining of the maxillary sinus. On the face some branches ascend to supply the lower eyelid and lacrimal sac while others decend to supply the upper lip.

The **descending palatine artery** descends through the pterygopalatine canal with the anterior palatine nerve and gives off smaller palatine arteries which accompany the middle and posterior palatine nerves to the soft palate and palatine tonsil. The remaining portion of the artery is called the *great palatine artery* which emerges from the greater palatine foramen and passes forwards to the incisive foramen through which it ascends to anastomose with the terminal part of the nasopalatine artery. Its branches are distributed to the gums, mucous membrane and glands of the palate.

The **artery of the pterygoid canal** (Vidian artery) passes backwards in company with the nerve of the same name, through the pterygoid canal and supplies the mucous membrane of the nasal part of pharynx and the auditory tube. It sends a twig to supply the tympanic cavity.

The **pharyngeal artery** passes backwards through the pharyngeal canal and is distributed to the pharynx and auditory tube.

The **sphenopalatine artery** passes medialwards through the sphenopalatine foramen and enters the nasal cavity where it gives off *lateral posterior nasal branches* which supply the lateral wall of the nasal cavity and *septal posterior nasal branches* which supply the nasal septum.

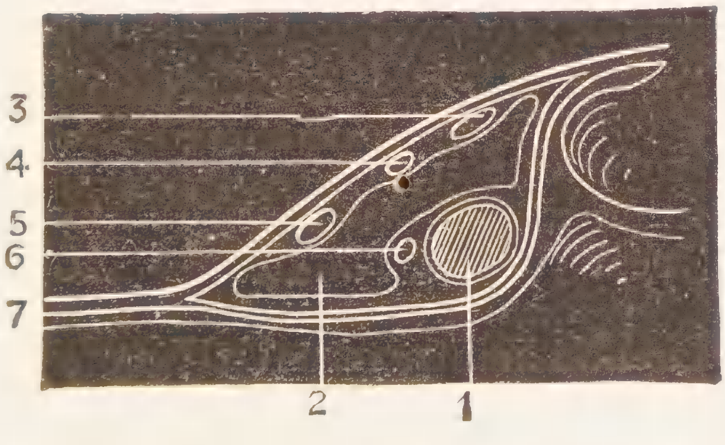
The **internal carotid artery** (Fig. 216) commences at the bifurcation of the common carotid and runs almost vertically upwards to enter the carotid canal in the petrous portion of the temporal bone. After its exit from the carotid canal it runs through the cavernous sinus along the carotid sulcus of the sphenoid, reaches the brain by piercing the dura mater medial to the anterior clinoid process, and terminates at the medial extremity of the lateral cerebral fissure by dividing into the anterior and middle cerebral arteries. For convenience of description the internal carotid artery is divided into four portions :

the portion that lies in the neck is called the *cervical portion* ; the portion in the carotid canal of the petrous bone, the *petrous portion ;* the portion in the cavernous sinus, the *cavernous portion ;* and the terminal portion in the brain, the *cerebral portion.*

The **cervical portion** of the artery has *in front* the skin, superficial fascia, the platysma, the sternocleidomastoideus, the parotid gland, the stylopharyngeus, the stylohyoideus and the posterior belly of the digastricus. It is crossed by the hypoglossal and glossopharyngeal nerves, the occipital and posterior auricular arteries. *Behind* it lies against the longus capitis and the sympathetic trunk. On its *lateral side* is the internal jugular vein but is separated from the vein near the base of the skull by the glossopharyngeal, vagus, accessory and hypoglossal nerves. On its *medial side* are the pharynx, the palatine tonsil, and the ascending pharyngeal artery. The external carotid artery is situated anterior and lateral to the internal carotid—the two arteries are separated by the styloglossus, stylopharyngeus, styloid process, glossopharyngeal nerve, pharyngeal branch of the vagus and some sympathetic twigs.

The **petrous portion** is contained within the carotid canal ; it first ascends vertically and then turns forwards and medialwards ; it next turns upwards and enters the cranial cavity through the foramen lacerum where it enters upon the cavernous portion of its course. It lies anteroinferior to the tympanum and cochlea ; posteromedial to the auditory tube ; and below the semilunar ganglion. The artery is surrounded by the internal carotid plexus of nerves derived from the sympathetic and also by a number of small veins.

The **cavernous portion** (Fig. 217) lies in the lateral surface of the body of the sphenoid between the two layers of the dura mater forming the cavernous sinus. It passes forwards between the two layers along the medial wall of the cavernous sinus and is separated here from the blood of the sinus by the lining membrane of the sinus. Reaching the medial side of the anterior clinoid process it passes upwards and pierces the dura mater and enters upon the cerebral portion of its course. The artery is surrounded by the cavernous plexus of the sympathetic. The



1. Internal carotid artery.
2. Lumen of the cavernous sinus.
3. Oculomotor nerve.
4. Trochlear nerve.
5. Ophthalmic nerve.
6. Abducent nerve.
7. Dura mater.

Fig. 217.—The internal carotid artery in the cavernous sinus.

abducent, oculomotor, trochlear, and ophthalmic nerves all lie lateral to it.

**Cerebral portion.**—Piercing the dura mater medial to the anterior clinoid process, the internal carotid artery runs between the optic and oculomotor nerves and below the anterior perforated substance to the medial extremity of the lateral cerebral fissure where it divides into the anterior and middle cerebral arteries.

**Branches.**—No branches are given off from the cervical portion of the internal carotid artery. The branches from the other portions may be arranged thus :—

| *From the petrous portion* | *From the cavernous portion* | *From the cerebral portion* |
|---|---|---|
| Caroticotympanic | Cavernous | Anterior cerebral |
| Pterygoid. | Semilunar | Middle cerebral |
| | Hypophysial | Posterior communicating |
| | Anterior meningeal | Anterior chorioidal |
| | Ophthalmic | |

The **caroticotympanic branch** is a minute branch ; it enters the tympanic cavity through a minute foramen in the posterior wall of the carotid canal.

The **pterygoid branch** is a small twig ; it passes into the pterygoid canal with the nerve of the pterygoid canal.

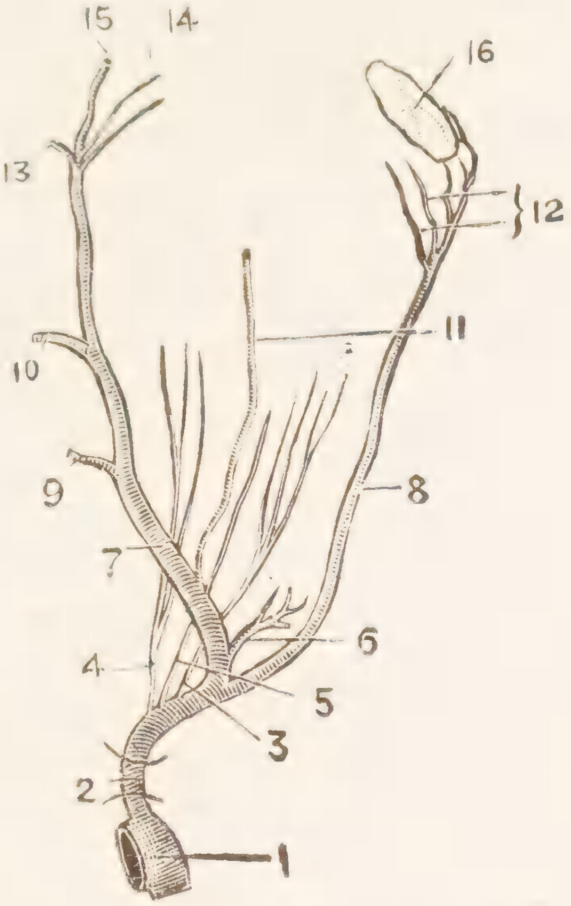
The **cavernous branches** are small twigs which supply the walls of the cavernnus sinus.

The **semilunar branches** are small twigs which supply the semilunar ganglion.

The **hypophysial branches** supply the hypophysis.

The **anterior meningeal branch** crosses the small wing of the sphenoid and supplies the duramater of the anterior fossa of the base of the skull.

The **ophthalmic artery** (Fig. 218) arises from the internal carotid artery on the medial side of the anterior clinoid process and enters the orbit through the optic foramen in company with the optic nerve lying immediately below and lateral to it. The vessel then crosses the optic nerve obliquely from its lateral to the medial side in company with the nasociliary nerve, runs forwards along the medial wall of the orbit beneath the lower border of the superior oblique muscle and divides into two terminal branches, the frontal and dorsal nasal arteries. The **branches** of the ophthalmic artery are ten in number. (1) The *lacrimal artery* arises near the optic foramen and passes forwards in company with the lacrimal nerve to the lacrimal gland which it supplies as well as the conjunctiva. It gives off (a) two *lateral palpebral branches* which run medialwards, one in each eyelid, near its free margin and form an arterial arch, *arcus tarseus*, by anastomosing with the medial palpebral branches of the ophthalmic artery ; (b) *muscular branches* to the neighbouring muscles ; (c) one or two *zygomatic branches* which emerge from the orbit through a foramen in its lateral wall ; (d) a *recurrent meningeal branch* which enters the cranial cavity through the lateral part of the superior orbital fissure to supply the dura mater. (2) The *arteria centralis retinae* is a very small branch which pierces the under



1. Internal carotid artery.
2. Ophthalmic artery.
3. 4. Posterior ciliary arteries.
5. Arteria centralis retinæ.
6. Muscular branches.
7. Ophthalmic artery.
8. Lacrimal artery.
9. Posterior ethmoidal artery.
10. Anterior ethmoidal artery.
11. Supraorbital artery.
12. Lateral palpebral arteries.
13. Dorsal nasal artery.
14. Medial palpebral arteries.
15. Frontal artery.
16. Lacrimal gland.

Fig. 218.—Diagram of the ophthalmic artery and its branches.

surface of the optic nerve about half an inch behind the eyeball and proceeds forwards in the substance of the nerve to the retina. (3) The *muscular branches* supply the muscles of the orbit. Some of them arise from the parent trunk while others are derived from its lacrimal and supraorbital branches. These muscular branches give off the *anterior ciliary arteries* which form an arterial anastomosis beneath the conjunctiva and then pierce the sclera behind the sclerocorneal junction. (4) The *posterior ciliary arteries* arise by two trunks which subdivide into numerous branches. These branches pierce the sclera around the entrance of the optic nerve to supply the chorioid and ciliary processes. Two of these branches are longer than the others and are called the *long posterior ciliary arteries.* (5) The *supraorbital artery* arises as the ophthalmic artery crosses the optic nerve. In company with the nerve of the same name it runs between the periosteum and the levator palpebræ superioris to the supraorbital notch or foramen. It passes through the notch and reaches the forehead where it supplies the scalp and muscles. In the orbit it gives off muscular branches to the neighbouring muscles. (6) The *anterior ethmoidal artery* accompanies the anterior ethmoidal nerve and passes through the anterior ethmoidal canal and supplies the anterior and middle ethmoidal cells and the frontal sinus. Inside the cranium it gives off an *anterior meningeal branch* which supplies the dura mater. Entering the nasal cavity it gives off nasal branches to supply the mucous membrane of the nose and ultimately appears on the side of the nose between the lower border of the nasal bone and the lateral nasal cartilage. (7) The *posterior ethmoidal artery* passes through the posterior ethmoidal canal and supplies the posterior ethmoidal cells. Entering the cranium it gives off a meningeal branch to the dura mater and nasal branches which, passing through the apertures in the lamina cribrosa of the ethmoidal bone, supply the upper part of the nasal cavity. (8) The *medial palpebral arteries* are two in number, a superior and an inferior. They arise close to the pulley of the superior oblique and run lateralwards, one in each eyelid near its free margin, to anastomose with the lateral palpebral branches. (9) The *frontal artery* is one of the terminal branches and accompanies the supratrochlear nerve. It emerges from the orbit at its medial angle and supplies the medial part of the forehead. (10) The *dorsal nasal artery* is the other terminal branch. It leaves the orbit at its medial angle and terminates on the side of the nose by anastomosing with the angular artery.

The **anterior cerebral artery** (Figs. 219, 220, 221) is the smaller of the two terminal divisions of the internal carotid. It runs forwards and medialwards above the optic nerve to the anterior extremity of the longitudinal fissure. Here it lies side by side with the artery of the opposite side and the two vessels are connected by a short transverse branch called the *anterior communicating artery*. In the remainder of its course it lies in close proximity with the artery of the opposite side—it proceeds forwards along the medial aspect of the frontal lobe and curving round the genu of the corpus callosum is continued backwards over the upper surface of the corpus callosum towards the splenium where it ends by anastomosing with the posterior cerebral artery. The **branches** given off from the anterior cerebral artery are :—(1) The *anteromedial ganglionic branches* are small twigs, which pass upwards pierce an area of grey substance, called the anterior perforated substance, and supply the anterior end of the caudate mucleus, the rostrum of the corpus callosum, and the septum pellucidum. (2) The *inferior frontal branches,* two or three in number, supply the medial part of the orbital surface of the frontal lobe and the olfactory tract and bulb. (3) The *anterior frontal branches* supply the anterior part of the medial surface and upper part of the lateral surface of the frontal lobe. (4) The *middle frontal branches* supply the medial surface of the frontal lobe behind the preceding branches. Its terminal twigs pass to the adjacent part of the lateral surface of the brain. (5) The *posterior frontal branches* supply the medial aspect of the brain in front of the parietooccipital fissure ; the terminal twigs supply the adjacent part of the lateral surface of the parietal lobe.

The **middle cerebral artery** (Figs. 219, 220, 221) proceeds along the lateral cerebral fissure at first lateralwards and then backwards and divides into several terminal branches on the insula. Its branches are :—(1) The *anterolateral ganglionic branches* which are numerous twigs. They pass upwards through the anterior perforated substance and supply certain grey masses called basal ganglia and the internal and external capsules. One of these branches is larger than the rest, passes between the lentiform nucleus and the external capsule and ends in the caudate nucleus ; this artery on account of its frequently rupturing in the brain is called the "artery of cerebral hæmorrhage". (2) The *inferior lateral frontal branches* supply the lateral part of the orbital surface and the lower part of the lateral surface of the frontal lobe. (3) The *ascending frontal branch* ramifies over the anterior central gyrus lying in front of the central sulcus. (4) The *ascending parietal branch* supplies the posterior central gyrus lying behind the central sulcus. (5) The *parietotemporal branch* supplies the inferior part of the parietal lobe and the posterior part of the temporal lobe.

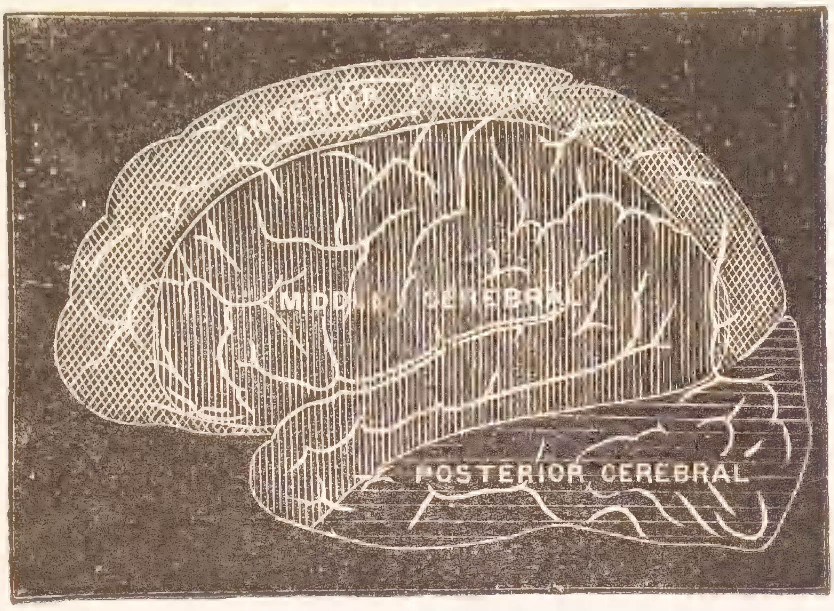


Fig. 220.—Diagram showing the distribution of cortical branches of cerebral arteries on the lateral surface of the cerebral hemisphere.

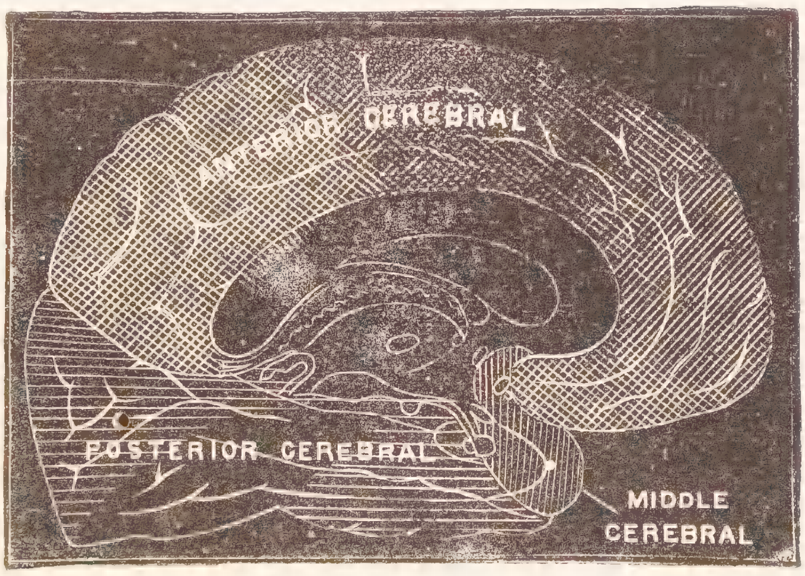
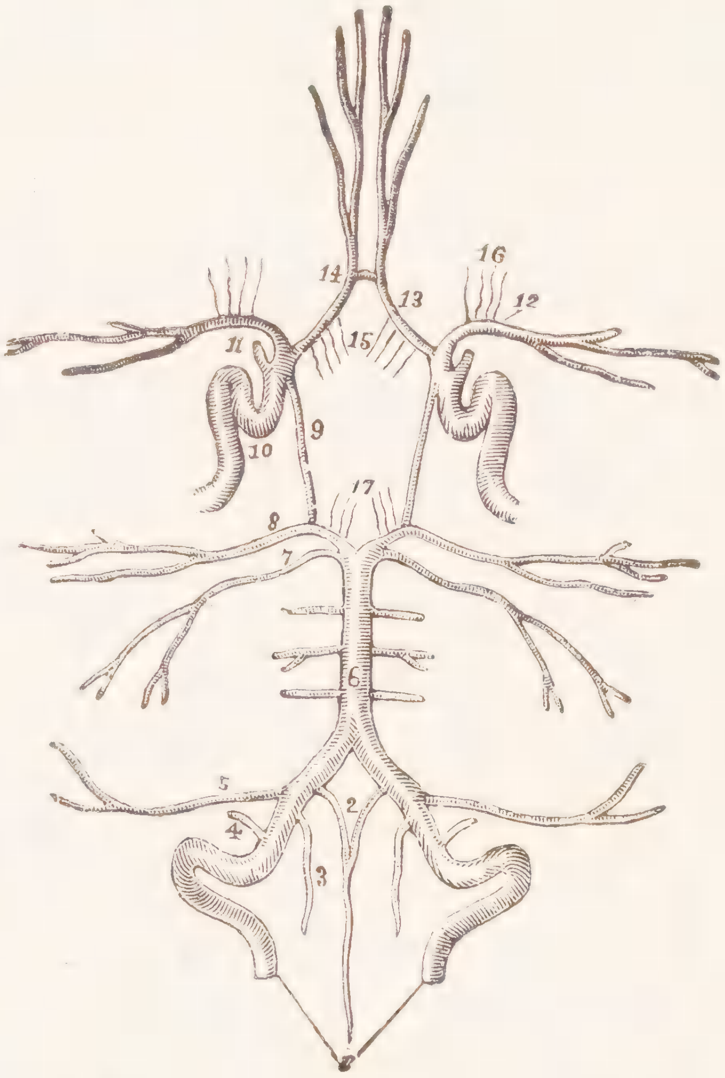


Fig. 221.—Diagram showing the distribution of cortical branches of cerebral arteries on the medial surface of the cerebral hemisphere.

(6) The *temporal branches* curve downwards to supply the front part of the lateral surface of the temporal lobe.

The **posterior communicating artery** (Fig. 219) is a slender branch which proceeds directly backwards to join the posterior cerebral artery. From it several minute posteromedial ganglionic branches are given off which supply the walls of the third ventricle and the medial surfaces of the thalami.

The **anterior chorioidal artery** issues from the internal carotid near the posterior communicating branch and passes backwards and lateralwards and enters the inferior cornu of the lateral ventricle to end in the chorioid plexus.



1. Vertebral arteries.
2. Anterior spinal branches uniting to form a single vessel.
3. Posterior spinal artery.
4. Meningeal branch of vertebral artery.
5. Posterior inferior cerebellar artery.
6. Basilar artery giving off pontine branches.
7. Superior cerebellar artery.
8. Posterior cerebral artery.
9. Posterior communicating branch of internal carotid artery.
10. Internal carotid artery.
11. Ophthalmic artery.
12. Middle cerebral artery.
13. Anterior cerebral artery.
14. Anterior communicating artery.
15. Antero-medial ganglionic branches of anterior cerebral artery.
16. Antero-lateral ganglionic branches of middle cerebral artery.
17. Postero-medial ganglionic branches of posterior cerebral artery.

Fig. 222.—Arteries of the brain and the arterial circle at the base of the brain.

**Circulus arteriosus** (circle of Willis) (Figs. 219, 222).—This important arterial anastomosis is situated at the base of the brain in the subarachnoid cavity above the pons. It is formed *in front* by the anterior cerebral arteries connected together by the anterior communicating artery; *laterally* by the posterior communicating arteries, each of which connects the internal carotid artery of the same side in front, and the posterior cerebral artery behind; *behind* by the two posterior cerebral arteries. On account of a complete anastomosis between the cerebral vessels in the circulus arteriosus, a free circulation of blood through the brain goes on at all times even if a large vessel on the side of the neck be obstructed.

It should be noted that two systems of arterial branches supply the brain. (1) The *cortical system* of branches supply the surfaces of the different lobes of the brain and send minute twigs penetrating for some depth into the interior to supply the subjacent brain substance. These vessels anastomose to some extent with each other. (2) The *ganglionic system* of branches penetrate the substance of the brain to supply the basal ganglia. These branches do not anastomose with each other and hence are called terminal arteries.

## THE ARTERIES OF THE SUPERIOR EXTREMITY

The arterial trunk of the superior extremity traverses the root of the neck where it is known as the subclavian artery, crosses the axillary space where it is called the axillary artery, and runs through the arm where it is termed the brachial artery, which divides into the radial and ulnar arteries in the forearm to be distributed to the forearm and hand.

### **The Subclavian Artery** (Figs. 213, 223)

The right subclavian artery arises from the bifurcation of the innominate artery behind the upper limit of the right sterno-clavicular joint. The left subclavian artery arises from the left end of the arch of the aorta behind the left common carotid artery. The scalenus anterior crosses each subclavian artery and divides it into three portions : the first portion extends from the origin of the artery to the medial margin of the scalenus anterior ; the second portion lies behind this muscle ; the third portion extends from the lateral margin of the muscle to the outer border of the first rib. The right subclavian artery is about 3 inches long while the left artery is about 4½ inches. In its course the artery describes an arch over the dome of the pleura. The height to which the artery rises in the neck is about ½ inch above the clavicle.

The **first portion of the right subclavian artery** arises from the bifurcation of the innominate and runs upwards and lateralwards to the medial margin of the scalenus anterior. It ascends in the neck about 1 inch above the clavicle and is very deeply placed. **Relations.**—The artery has *in front* the skin, superficial fascia, platysma, deep cervical fascia, clavicular origin of sternocleidomastoideus, sternohyoideus and sternothyreoideus. It is crossed by the internal jugular and vertebral veins near the scalenus anterior. It is crossed by the anterior jugular vein—the sternohyoideus and sternothyreoideus separating the vein from the artery. The vagus and the cardiac branches of the vagus and sympathetic cross it superficially while the nerve loop, called the ansa subclavia lies around the artery. *Behind* it are the longus colli, the first thoracic vertebra, the sympathetic nerve trunk, the right recurrent nerve, the apex of the right lung and pleura. *Below* it are the pleura and the right recurrent nerve.

The **first portion of the left subclavian artery** extends from the left end of the arch of the aorta to the medial margin of the scalenus anterior. It has therefore at first an additional intrathoracic portion. Within the thorax it is placed deeply in the superior mediastinum and ascends vertically to the root of the neck parallel to the thoracic portion of the left common carotid. Reaching the root of the neck it curves lateralwards over the dome of the pleura and reaches the medial margin of the scalenus anterior. **Relations of the vertical intrathoracic part.**—It has *in front* the left common carotid artery and the left innominate vein ; the left vagus, left phrenic and cardiac branches of the vagus and sympathetic are placed between it and the left common carotid artery. *Behind* it are the œsophagus and thoracic duct. On its *right side* are the trachea and the left recurrent nerve. On its *left side* are the left pleura and left lung. **Relations of the arched cervical part.**—It has *in front* the sternocleidomastoideus, sternohyoideus and sternothyroideus, the commencement of the left innominate vein and the left vertebral vein ; the phrenic nerve passes in front of the artery near the medial border of the scalenus anterior. *Behind* it are the left longus colli, the left sympathetic trunk and its inferior cervical ganglion. To its *right side* are the trachea, œsophagus, thoracic duct and left recurrent nerve.

The **second portion of the subclavian artery** lies behind the scalenus anterior muscle and forms the highest part of the arch reaching ½ inch above the clavicle. **Relations.**—*In front* of it are the skin, superficial fascia, platysma, fascia colli, sternocleidomastoideus and scalenus anterior and on the right side the phrenic nerve. *Behind* it are the pleura and lung. *Above* it is the brachial plexus of nerves. *Below* it are the pleura and lung. The scalenus anterior separates this portion of the artery from the subclavian vein which lies on a lower level.

The **third portion of the subclavian artery** extends from the lateral margin of the scalenus anterior to the outer border of the first rib, where it becomes the axillary artery. It runs downwards and lateralwards and is contained in the subclavian triangle except its terminal part (less than an inch) which passes beneath the clavicle and subclavius. It is more superficial than either the first or the second portion and consequently the artery is ligatured here when the surgeon has a choice. **Relations.**—*In front* it is covered by skin, superficial fascia, platysma and fascia colli, clavicle, and subclavius ; the transverse scapular artery crosses it from the medial to the lateral side ; the external jugular vein crosses it near the posterior border of the sternocleidomastoideus and receives the transverse cervical, transverse scapular, and anterior jugular veins which form a venous plexus in front of the artery ; the nerve to the subclavius crosses in front of the artery. The lowest trunk of the brachial plexus lies *behind* it and separates it from the scalenus medius. *Above* it are the upper and middle trunks of the brachial plexus. *Below* it rests upon the upper surface of the first rib. The subclavian vein lies anteriorly and inferiorly to the artery.

The **branches of the subclavian artery** are: (1) the vertebral, (2) the thyreocervical trunk, (3) the internal mammary, and (4) the costocervical artery. On the left side all the four branches arise from the first portion of the artery towards its termination. On the right side the first three branches arise from the first portion towards its termination but the costocervical trunk issues from the second portion.

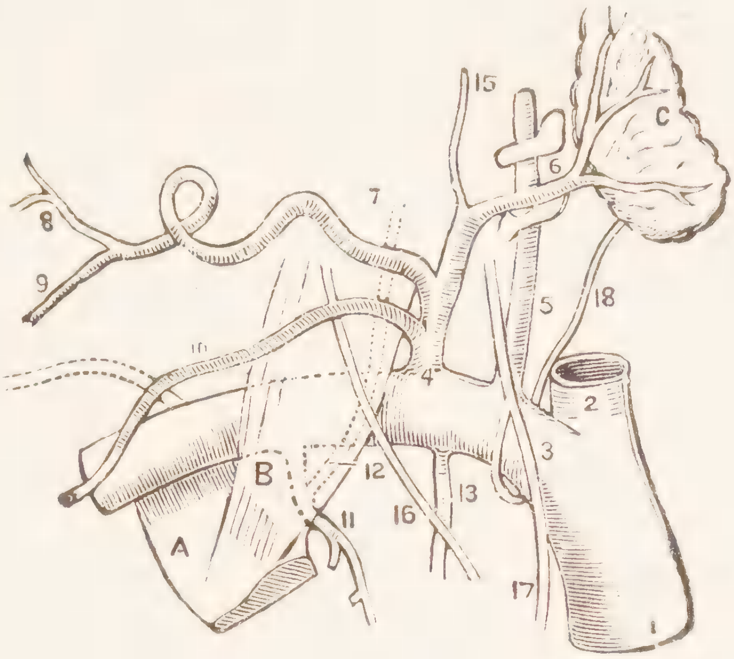


Fig. 223.—Diagram of the subclavian artery and its branches.

A. First rib.
B. Scalenus anterior.
C. Thyreoid body.
1. Innominate artery.
2. Right common carotid artery.
3. Right subclavian artery.
4. Thyreo-cervical trunk.
5. Vertebral artery.
6. Inferior thyreoid artery.
7. Transverse cervical artery.
8. Its ascending branch.
9. Its descending branch.
10. Transverse scapular artery.
11. Superior intercostal artery.
12. Arteria profunda cervicis.
13. Internal mammary artery.
15. Ascending cervical artery.
16. Phrenic nerve.
17. Vagus nerve.
18. Right recurrant nerve.

The **vertebral artery** (Figs. 216, 223) arises, on the right side, from the upper and back part of the first portion of the subclavian, about a quarter of an inch from the medial margin of the scalenus anterior, and on the left side, just after it enters the root of the neck. It ascends passing through the foramina transversaria of the upper six cervical vertebræ, and curves backwards and medialwards round the superior articular process of the atlas; passing through the foramen magnum it enters the cranial cavity and terminates at the lower border of the pons by uniting with its fellow of the opposite side to form the basilar artery. For purposes of description the vertebral artery is divided into four parts.

The **first** or **cervical part** extends from its origin to the foramen transversarium of the sixth cervical vertebra. It passes upwards between the contiguous borders of the scalenus anterior and longus colli and has *in front* the common carotid artery, the vertebral and internal jugular veins; it is crossed by the inferior thyreoid artery and on the left side by the thoracic duct. *Behind*, it lies on the transverse process of the seventh cervical vertebra and the sympathetic nerve trunk. *Medial* to it is the longus colli ; *lateral* to it is the scalenus anterior.

The **second or vertebral part** of the vertebral artery is situated in the foramina transversaria of the upper six cervical vertebræ. It ascends vertically through these foramina and is surrounded by a plexus of veins which form the vertebral vein and by the vertebral plexus of the sympathetic. Behind it are the trunks of the cervical nerves.

The **third or suboccipital part** of the vertebral artery begins from the point of exit of the vessel from the foramen transversarium of the atlas ; it then curves backwards behind the superior articular process of the atlas, lies in the sulcus arteriæ vertebralis on the posterior arch of that bone and passes under the posterior atlantooccipital membrane. This part of the artery is contained in the suboccipital triangle. After its exit from the foramen transversarium of the atlas it lies on the medial side of the rectus capitis lateralis ; the anterior ramus of the first cervical nerve lies to its medial side when it curves backwards behind the superior articular process ; the posterior division of the first cervical nerve lies beneath it on the posterior arch of the atlas.

The **fourth or intracranial part** of the vertebral artery begins from its point of exit from under cover of the posterior atlanto-occipital membrane ; it then pierces the duramater and arachnoid and enters the cranial cavity through the foramen magnum. During its passage through the foramen magnum it lies in front of the first process of the ligamentum denticulatum, and between the roots of the hypoglossal nerve and first cervical nerve. Piercing the arachnoid it passes to the front of the medulla oblongata and reaches the lower border of the pons where it unites with the artery of the opposite side to form the basilar artery.

The **branches** of the vertebral artery are : (1) muscular, (2) lateral spinal, (3) meningeal, (4) posterior spinal, (5) anterior spinal, (6) posterior inferior cerebellar, and (7) medullary.

The **muscular branches** which spring from the first portion are small and few in number ; those from the second portion supply the deep muscles of the neck and anastomose with the occipital, ascending cervical and profunda cervicis arteries ; those from the third portion supply the muscles of the suboccipital triangle.

The **lateral spinal branches** arise from the second part of the artery, pass through the intervertebral foramina into the vertebral canal and each divides into two branches : one of which passes to the posterior surface of the body of the vertebra ; the other supplies the medulla spinalis and its membranes.

The **meningeal branches**, one or two in number, spring from the fourth part of the artery before it pierces the dura mater. They ramify in the posterior fossa of the skull and anastomose with the meningeal branches derived from the occipital and ascending pharyngeal arteries.

The **posterior spinal artery** is a long slender artery which arises from the fourth portion of the vertebral ; it runs downwards along the side of the medulla oblongata and medulla spinalis behind the roots of the spinal nerves. It is reinforced by the spinal branches of the vertebral and intercostal arteries and can be traced up to the end of the medulla spinalis. It gives off branches which anastomose freely and form a chain round the posterior roots of the spinal nerves.

The **anterior spinal branch** arises from the vertebral near its termination, runs obliquely downwards and medialwards over the ventral aspect of the medulla oblongata and unites with its fellow of the opposite side to form a single trunk, the **anterior spinal artery**. This trunk runs downwards along the anterior median fissure of the medulla spinalis and can be traced as a fine twig as far as the filum terminale ; it is reinforced during its whole course by filaments from the lateral spinal branches of the vertebral, intercostal and lumbar arteries. It supplies the medulla spinalis and cauda equina.

The **posterior inferior cerebellar** is the largest branch of the vertebral ; it arises a little below the pons, runs backwards round the medulla oblongata between the filaments of the vagus and accessory nerves, then over the restiform body and reaches the vallecula of the cerebellum where it divides into two branches, medial and lateral. The *medial branch* runs backwards, supplies the vermis and anastomoses with its fellow of the opposite side. The *lateral branch* runs lateralwards, supplies the lower surface of the hemispheres of the cerebellum and anastomoses with the anterior inferior cerebellar and superior cerebellar branches of the basilar artery. Branches are given off to the medulla oblongata and the chorioid plexus of the fourth ventricle from the trunk of the posterior inferior cerebellar artery.

**Medullary branches** are given to the medulla oblongata from the trunk and branches of the vertebral artery.

The **basilar artery** (Figs. 219, 222) is formed by the union of the right and left vertebral arteries at the lower border of the pons ; it extends up to the upper border of the pons occupying the median groove on its ventral aspect and divides into the two posterior cerebral arteries. It lies within the cisterna pontis and is placed between the two abducent nerves below and between the two oculomotor nerves above. Its **branches** are : (1) pontine, (2) internal auditory, (3) anterior inferior cerebellar, (4) superior cerebellar, (5) posterior cerebral.

The **pontine branches** are several small twigs which proceed from either side of the basilar artery and supply the pons, the roots of the trigeminal nerve and the brachium pontis.

The **internal auditory artery** is a long slender vessel, one on each side. It arises from the middle of the basilar artery, passes through the internal acoustic meatus with the facial and acoustic nerves and supplies the internal ear.

The **anterior inferior cerebellar artery** arises, one on each side, from near the middle of the basilar artery and runs backwards to supply the anterior part of the inferior surface of the cerebellum. It anastomoses with the posterior inferior cerebellar artery, which is a branch of the vertebral.

The **superior cerebellar artery** arises, one on each side, near the termination of the basilar. It runs lateralwards parallel to the posterior cerebral artery—the oculomotor nerve lying between the two vessels. It then curves round the lateral side of the cerebral peduncle below the trochlear nerve, reaches the upper surface of the cerebellum and divides into two branches, medial and lateral. The medial branch anastomoses with its fellow of the opposite side and supplies the vermis and anterior medullary velum. The lateral branch anastomoses with the inferior cerebellar arteries and supplies the lateral lobe of the cerebellum.

The **posterior cerebral artery** is one of the two terminal branches of the basilar artery. It begins at the upper border of the pons and runs lateralwards in front of the occulomotor nerve which separates it from the superior cerebellar artery. It curves round the cerebral peduncle and lies between the peduncle and the hippocampal gyrus and above the trochlear nerve. It then proceeds to be distributed to the tentorial and medial surfaces of the occipital lobe of the cerebrum. The posterior communicating branch of the internal carotid artery runs backwards and joins it near its commencement.

The **branches** of the posterior cerebral artery can be divided into two groups: the central or ganglionic and peripheral or cortical.

The *ganglionic group* consists of: (1) the *posteromedial branches* which pass medial to the cerebral peduncle, perforate the posterior perforated substance and are distributed to the walls of the third ventricle and medial portion of the optic thalamus; (2) the *posterolateral ganglionic branches* which pass lateral to the cerebral peduncle and supply the thalamus and corpora quadrigemina; (3) the *posterior chorioidal branches* which pass through the chorioidal fissure, supply the tela choriodea of the third ventricle and end in the chorioid plexus in the body of the lateral ventricle.

The *cortical group* consists of: (1) the *anterior temporal branch* which supplies the uncus and fusiform gyrus; (2) the *posterior temporal branch* which supplies the hippocampal gyrus, part of the fusiform gyrus and lingual gyrus; (3) the *calcarine branch* which passes along the calcarine fissure as the continuation of the parent trunk and supplies the cuneus, lingual gyrus and posterior part of the lateral surface of the occipital lobe; (4) the *parietooccipital branch* which passes

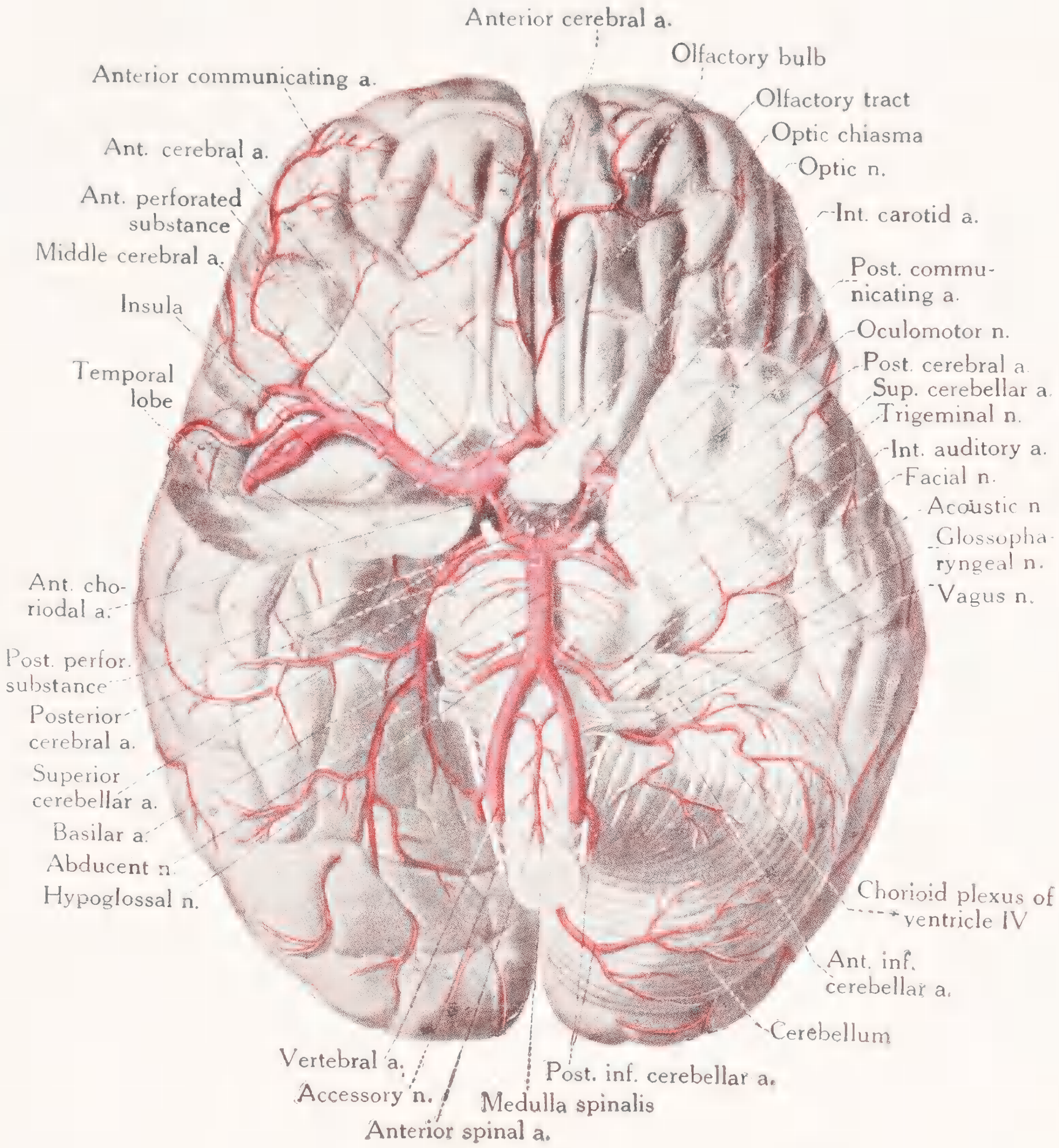


Fig. 219.—The arteries at the base of the brain.

To face p. 396.

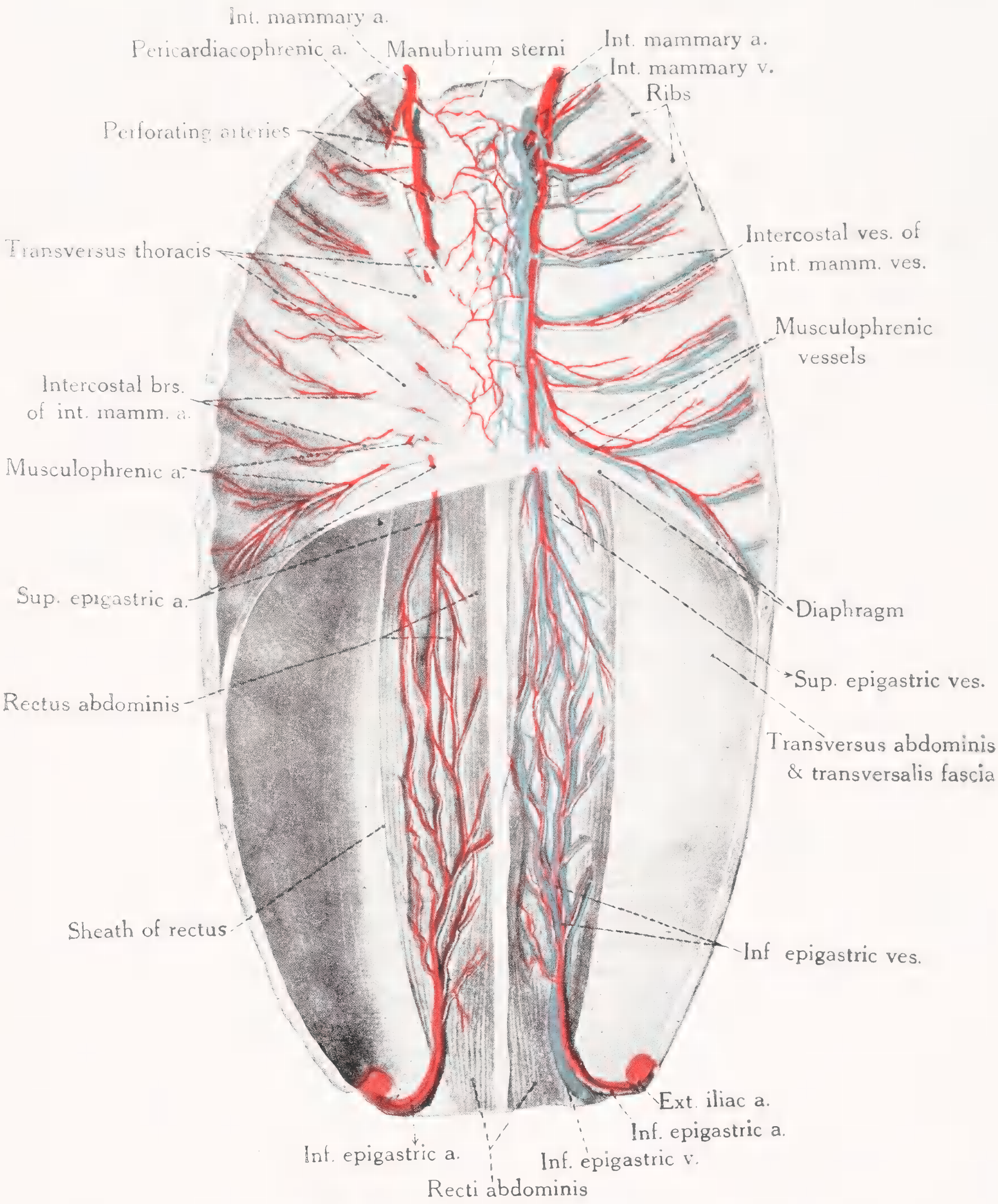


Fig. 224.—The internal mammary artery.

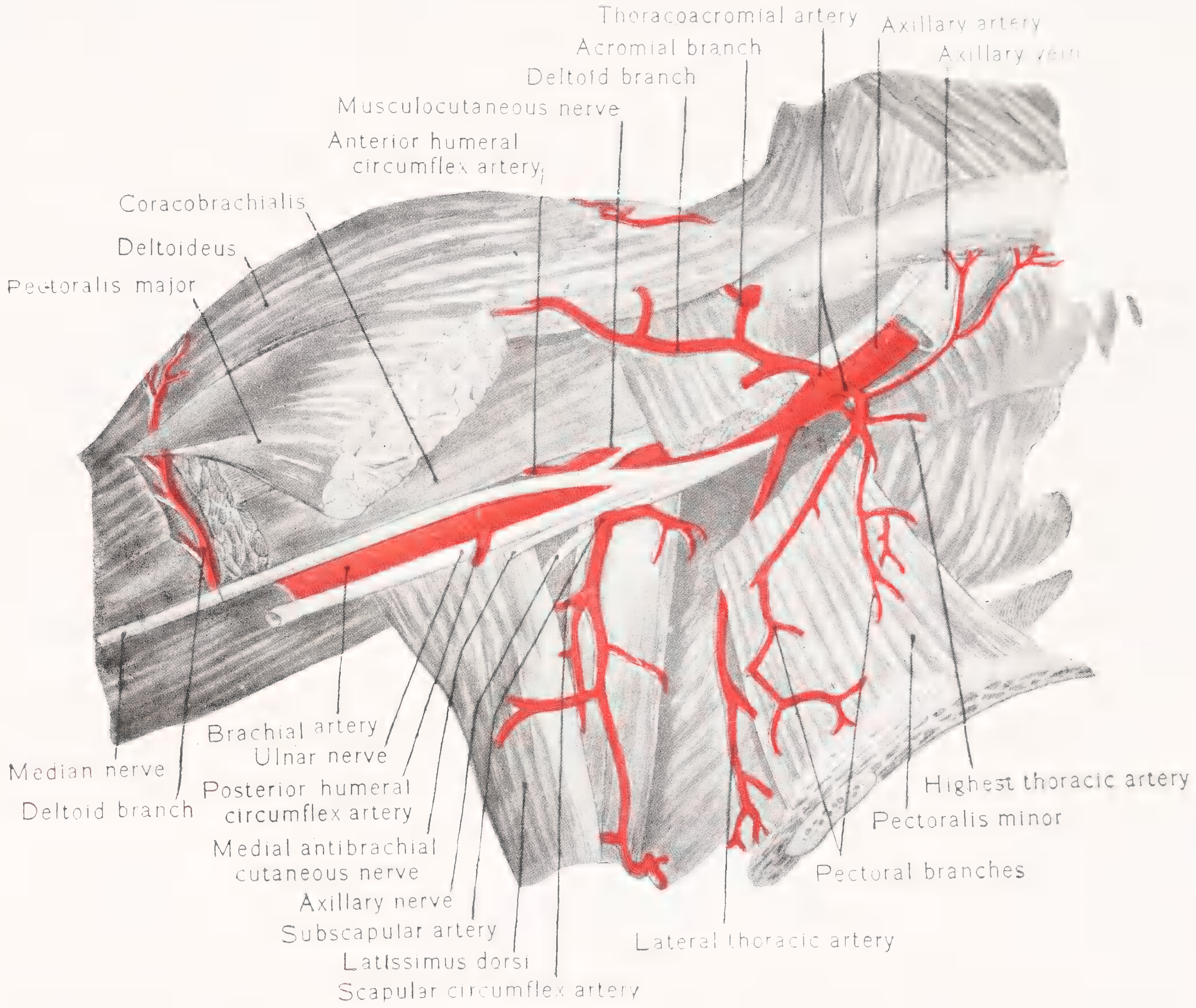


Fig. 225.—The axillary artery and its branches.

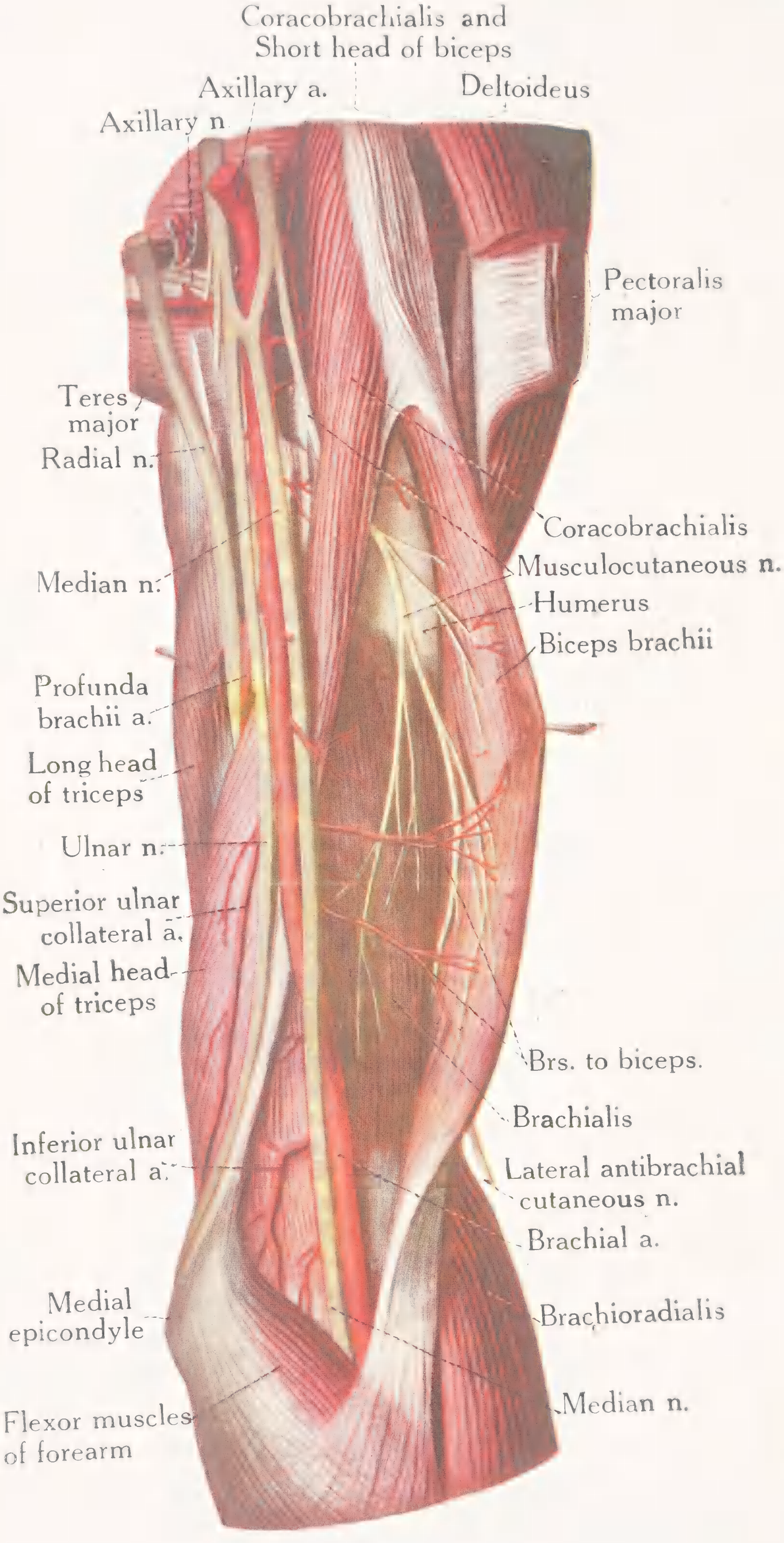


Fig. 226.—The brachial artery.

along the fissure of the same name and supplies the cuneus and precuneus.

The **thyreocervical trunk** (thyreoid axis) (Figs. 213, 223) springs from the upper and anterior aspect of the first portion of the subclavian artery close to the medial margin of the scalenus anterior and opposite the origin of the internal mammary artery. It is a short, thick trunk (about 5 mm. long) and divides almost immediately into three radiating branches—the inferior thyreoid, transverse cervical, and transverse scapular (suprascapular).

The **inferior thyreoid artery** ascends along the medial margin of the scalenus anterior; it then passes medialwards behind the carotid sheath and its contents, the sympathetic trunk and the middle cervical ganglion, and finally descends as far as the lower border of the lateral lobe of the thyreoid gland, where it comes to lie in relation with the recurrent nerve either anteriorly or posteriorly. It gives off the following *branches*:—

(1) The *muscular branches* supply the scalenus anterior, longus colli, inferior constrictor of the pharynx, and depressors of the hyoid bone.

(2) The *oesophageal branches* are distributed to the œsophagus and anastomose with the œsophageal branches of the descending thoracic aorta.

(3) The *tracheal branches* supply the trachea and anastomose with the bronchial arteries.

(4) The *ascending cervical artery* arises from the inferior thyreoid artery as that vessel passes behind the carotid sheath. It ascends in front of the transverse processes of the cervical vertebræ between the scalenus anterior and longus capitis, parallel and medial to the phrenic nerve. It supplies those muscles and gives off spinal branches which are distributed like the lateral spinal branches of the vertebral artery. It anastomoses with the vertebral, ascending pharyngeal and deep cervical arteries.

(5) The *inferior laryngeal artery* runs upwards along the trachea accompanied by the recurrent nerve and enters the laryx beneath the lower border of the inferior constrictor of the pharynx. It supplies the muscles and mucous membrane of the larynx and anastomoses with its fellow of the opposite side and with the superior laryngeal branch of the superior thyreoid artery.

(6) The *glandular branches* supply the thyreoid gland and anastomose with the arteries of the opposite side and with the superior thyreoid artery; one of the branches supplies the parathyreoid glands.

The **transverse cervical artery** (Figs. 213, 223) runs transversely lateralwards on a higher level than the transverse scapular and a little above the clavicle. After its origin it lies under cover of the sternocleidomastoideus and runs in front of the phrenic nerve and scalenus anterior. Leaving the cover of the muscle it passes through the subclavian triangle lying behind the inferior belly of the omohyoideus and in front of the trunks of the brachial plexus. Finally it runs further lateralwards to reach the deep surface of the trapezius and at the anterior margin of the levator scapulæ it divides into an ascending and a descending branch.

The *ascending branch* (superficial cervical artery) runs upwards beneath the trapezius and rests upon the levator scapulæ and the splenius. It supplies these muscles and neighbouring lymph glands and anastomoses with the descending branch of the occipital artery. This artery frequently springs from the thyreocervical trunk.

The *descending branch* (posterior scapular artery) runs backwards beneath the levator scapulæ. Reaching the medial angle of the scapula it courses downwards under cover of the rhomboid muscles along the vertebral border of the scapula to the inferior angle of the bone where it anastomoses with the subscapular artery. It supplies branches to the neighbouring muscles and gives off branches on the ventral and dorsal surfaces of the scapula which take part in the formation of the scapular anastomoses. This artery may arise directly from the third part of the subclavian.

The **transverse scapular artery** (Figs. 213, 223) runs at first downwards and lateralwards lying in front of the phrenic nerve and scalenus anterior and behind the sternocleidomastoideus. It then continues its course lateralwards behind the clavicle, lying in front of the third portion of the subclavian artery and cords of the brachial plexus, to reach the scapular notch where it passes over (occasionally under) the superior transverse ligament of the scapula. Then it descends in company with the suprascapular nerve to the supraspinatous fossa lying beneath the supraspinatus, passes through the great scapular notch and reaches the infraspinatous fossa where it anastomoses with the descending branch of the transverse cervical artery and scapular circumflex artery beneath the infraspinatus muscle. It gives off *articular branches* to the acromioclavicular and shoulder joints; *nutrient branches* to the clavicle and scapula; *muscular branch* to the sternocleidomastoideus, subclavius, supraspinatus, and infraspinatus; *subscapular branch* which ramifies in the subscapular fossa beneath the subscapularis; *suprasternal branch* to the sternal end of the clavicle; *acromial branches* which ramify over the acromion; *supraspinous* and *infraspinous branches* which ramify over the supraspinatous and infraspinatous fossæ.

The **internal mammary artery** (Figs. 223, 224) arises from the lower aspect of the first portion of the subclavian artery opposite the thyreocervical trunk, close to the medial margin of the scalenus anterior. At first it descends inclining forwards and medialwards behind the innominate vein, the sternal end of the clavicle and the cartilage of the first rib and rests upon the pleura—the phrenic nerve crosses obliquely in front of the artery from the lateral to the medial side. This constitutes the *cervical* *part* of the artery. It next descends vertically about half an inch lateral to the border of the sternum behind the cartilages of the next succeeding ribs to the sixth intercostal space where it terminates by dividing into two branches, the musculophrenic and superior epigastric. This constitutes the *thoracic part* of the artery, the relations of which are :—*in front* it is covered by the pectoralis major, cartilages of the upper six ribs, anterior intercostal membranes, internal intercostal muscles, and terminal portions of the upper six intercostal nerves ; *behind* it are the pleura and transversus thoracis. The internal mammary artery is accompanied by the sternal lymph glands and by two venæ comites which unite into one trunk and ends in the corresponding innominate vein.

**Branches.**—The internal mammary artery does not give off any branch in the neck. In the thorax it gives off the following branches :—

(1) The *pericardiacophrenic artery,* (comes nervi phrenici) is a long slender vessel which arises high up. It accompanies the phrenic nerve to the diaphragm lying between the pericardium and pleura and anastomoses with the inferior phrenic and musculophrenic arteries. It supplies the pericardium, pleura and diaphragm.

(2) The *anterior mediastinal branches* supply the remains of the thymus gland and the areolar tissue and lymph glands in the anterior mediastinum.

(3) The *sternal branches* supply the sternum and transversus thoracis.

(4) The *perforating branches,* six in number, arise opposite each of the upper six intercostal spaces. Each artery pierces the internal intercostal muscle, anterior intercostal membrane and pectoralis major. It then runs lateralwards to supply the skin of the pectoral region. The arteries of the second, third and fourth intercostal spaces give branches to the mammary gland.

(5) The *pericardial branches* supply the anterior aspect of the pericardium.

(6) The *anterior intercostal arteries* are two in number in each of the upper six intercostal spaces which pass lateralwards, one lying along the lower margin of the costal cartilage above and the other along the upper margin of the cartilage below, behind the internal intercostal muscle. They then pierce this muscle and lie between the external and internal intercostal muscles and anastomose with the intercostal branches of the aorta or of the arteria intercostalis suprema.

(7) The *musculophrenic artery,* is the lateral terminal branch of the internal mammary artery. It runs obliquely downwards and lateralwards behind the seventh, eighth, ninth and tenth costal cartilages and terminates in the abdominal surface of the diaphragm which it pierces opposite the ninth costal cartilage. It gives off *anterior intercostal branches* which are two in

number in each of the seventh, eighth and ninth intercostal spaces and are distributed in the same manner as the anterior intercostal branches of the internal mammary. It supplies the diaphragm and the muscles of the anterolateral region of the abdomen.

(8) The *superior epigastric artery*, is the medial terminal branch of the internal mammary artery. It descends between the sternal and costal origins of the diaphragm, enters the sheath of the rectus abdominis lying at first behind the muscle and lower down entering the substance of the muscle where it anastomoses with the inferior epigastric artery, a branch of the external iliac. It gives off (*a*) muscular branches to the diaphragm and muscles of the anterior abdominal wall; (*b*) cutaneous branches which accompany the anterior cutaneous branches of the lower six thoracic nerves; (*c*) a xiphoid branch which anastomoses with its fellow of the opposite side; (*d*) falciform branch which passes to the liver in the falciform ligament and anastomoses with the hepatic artery.

The **costocervical artery** (Fig. 216) arises from the posterior aspect of the second portion of the subclavian artery close to the medial border of the scalenus anterior on the right side. On the left side it springs from the first portion of the parent trunk. It passes backwards above the apex of the cervical pleura towards the neck of the first rib and divides into the arteria cervicalis profunda and arteria intercostalis suprema.

The *arteria cervicalis profunda* passes backwards between the eighth cervical and first thoracic nerves and between the transverse process of the seventh cervical vertebra and neck of the first rib. It then ascends in the back of the neck between the semispinalis capitis and the semispinalis cervicis to the level of the epistropheus where it anastomoses with the descending branch of the occipital artery and branches of the vertebral artery. It gives off muscular branches and a spinal branch which enters the vertebral canal through the intervertebral foramen between the seventh cervical and first thoracic vertebræ. This artery is homologous with the posterior branch of an aortic intercostal artery.

The *arteria intercostalis suprema* (superior intercostal artery) passes downwards into the thorax in front of the neck of the first rib lying between the first thoracic ganglion of the sympathetic medially and the first intercostal nerve laterally. Here it gives off the *first intercostal artery* which runs along the first intercostal space. It then crosses the neck of the second rib and becomes the *second intercostal artery* which runs along the second intercostal space. The course and distribution of the first and second intercostal arteries resemble the succeeding intercostal arteries derived from the descending thoracic aorta —each lies first between the pleura and intercostal membrane and then between the internal and external intercostal muscles. Each gives off (1) a *posterior branch* which furnishes first a *spinal branch* for the supply of the medulla spinalis and then divides into a *medial* and a *lateral branch* which pass in company with the corresponding branches of the posterior division of a thoracic spinal nerve; (2) a *collateral branch* which issues midway between the vertebral column and sternum and descends to the upper border of the rib below; (3) a *lateral cutaneous branch* which accompanies the lateral cutaneous branch of an intercostal nerve; (4) *muscular branches* which supply the intercostal muscles.

### The Axillary Artery (Fig. 225)

The **axillary artery** is the continuation of the subclavian artery and extends from the outer border of the first rib to the lower border of the teres major where it becomes the brachial artery. Its direction and to a certain extent its relations vary with the position of the upper limb: it is only when the arm is at a right angle with the trunk that the direction of the artery is that of a straight line and in this position it is overlapped by the axillary vein anteriorly and medially. If the arm is raised above the shoulder the artery describes a curve with the concavity upwards and the axillary vein comes to lie in front of it. The axillary artery is enclosed together with the axillary vein and the brachial plexus within a fascial sheath, called the *axillary sheath,* which is continuous with the fascia colli above and blends with the deep surface of the coracoclavicular fascia below. The axillary artery is crossed by the pectoralis minor and is divided into three parts, first, second, and third according as it lies above, beneath, and below this muscle.

The **first part** of the axillary artery extends from the outer border of the first rib to the upper margin of the pectoralis minor. *In front* it is covered by the clavicular part of the pectoralis major and the coracoclavicular fascia; it is crossed by the cephalic vein, and the loop of communication between the lateral and medial anterior thoracic nerves lies in front of it. *Behind* it rests upon the first intercostal space, the first and second digitations of the serratus anterior; the medial cord of the brachial plexus, the long thoracic nerve and medial anterior thoracic nerve pass medialwards behind the vessel. To its *lateral side,* and on a higher plane are the lateral and posterior cords of the brachial plexus. To its *medial side* and on a lower plane is the axillary vein which slightly overlaps it.

The **second part** of the axillary artery lies behind the pectoralis minor. *In front* it is covered by the pectoralis major and minor. *Behind* it is in contact with the posterior cord of the brachial plexus and a quantity of fat which separates it from the subscapularis. *Lateral* to it is the lateral cord of the brachial plexus. *Medial* to it is the medial cord of the brachial plexus which separates it from the axillary vein. It is worthy of note that the second part of the artery is surrounded on three sides by the three cords of the brachial plexus, one lying behind, one medially, and one laterally.

The **third part** of the axillary artery extends from the lower border of the pectoralis minor to the lower border of the teres major. Its upper half lies deeply placed within the axilla under cover of the pectoralis major; its lower half lies superficially placed in the arm being covered only by skin and superficial and deep fasciæ. *In front* it is covered by pectoralis major and fasciæ and skin; it is crossed in front by the medial head of the median nerve. *Behind* it rests upon the subscapularis, latissimus dorsi, and teres major in that order from above downwards; it lies over the axillary nerve above and the radial nerve below—the nerves intervene between the muscles and the artery. To its *lateral side* are the coracobrachialis, the median and the musculocutaneous nerves. To its *medial side* are the medial antibrachial cutaneous, ulnar and medial brachial cutaneous nerves which separate the artery from the axillary vein.

**Branches.**—The branches of the axillary artery are: from the first part (1) the highest thoracic; from the second part (2) the thoracoacromial and (3) lateral thoracic; from the third part (4) the subscapular, (5) anterior humeral circumflex, and (6) the posterior humeral circumflex.

The **highest thoracic artery** (superior thoracic artery) is a small branch which arises near the lower border of the subclavius, runs downwards and medialwards to the first intercostal space and supplies the pectoralis major and minor, serratus anterior and intercostal muscles. It anastomoses with the internal mammary and intercostal arteries.

The **thoracoacromial artery** (thoracic axis) is a short trunk which arises from the front of the axillary artery, above the upper border of the pectoralis minor. It runs forwards, pierces the coracoclavicular fascia and divides into four branches, named from their direction—deltoid, acromial, clavicular, pectoral. The *deltoid* (*humeral*) *branch* passes downwards by the side of the cephalic vein along the interval between the pectoralis major and deltoideus and supplies both the muscles. The *acromial branch* passes lateralwards beneath the deltoideus and supplies it; it then pierces the muscle and ramifies over the acromion where it anastomoses with the branches of the transverse scapular and posterior humeral circumflex arteries and forms an arterial network called the *acromial rete*. The *clavicular branch* passes upwards and medialwards beneath the clavicle and supplies the subclavius muscle and sternoclavicular joint. The *pectoral branch* passes between the two pectoral muscles, supplies them and anastomoses with the lateral thoracic and intercostal arteries.

The **lateral thoracic artery** (long thoracic artery) runs downwards and medialwards along the lower border of the pectoralis minor to the thoracic wall and supplies the pectoral muscles and the serratus anterior. It anastomoses with the intercostal and subscapular arteries. In the female it gives off a large branch, called the *external mammary artery*, which winds round the lower border of the pectoralis major and supplies the mammary gland.

The **subscapular artery,** the largest of all the branches of the axillary, arises close to the lower border of the subscapularis and descends along this border to the inferior angle of the scapula where it anastomoses with the descending branch of the transverse cervical artery. It is accompanied, in the lower part of its course, by the thoracodorsal nerve. It supplies the muscles of the posterior wall of the axilla and serratus anterior. In addition to these muscular branches it gives off about an inch from its origin a large branch, called the scapular circumflex artery.

The **scapular circumflex artery** (dorsalis scapulæ) runs backwards through the *triangular space* bounded above by the subscapularis and teres minor, below by the teres major, and laterally by the long head of the triceps. It turns round the axillary border of the scapula grooving the bone and then enters the infraspinatous fossa by passing through the teres minor and anastomoses with the transverse scapular and descending branch of the transverse cervical arteries. In the triangular space it gives off an *infrascapular branch* which enters the subscapular fossa beneath the subscapularis and ends by anastomosing with the transverse scapular and descending branch of the transverse cervical arteries. In the same triangular space it gives off a *descending branch* which runs downwards to the inferior angle of the scapula between the teres minor and teres major muscles and anastomoses with the descending branch of the transverse cervical artery.

The **anterior humeral circumflex artery,** usually a small artery, arises from the lateral aspect of the axillary artery below the subscapular artery. It passes lateralwards beneath the coracobrachialis and short head of the biceps brachii in front of the surgical neck of the humerus and, reaching the intertubercular sulcus, it gives off an *ascending branch* which runs upwards in the sulcus to supply the long head of the biceps brachii and the shoulder joint. After crossing the intertubercular sulcus it winds round the surgical neck of the humerus and ends by anastomosing with the posterior humeral circumflex artery.

The **posterior humeral circumflex artery,** an artery of large size, arises from the back of the axillary artery a little below the subscapular artery. It passes backwards with the axillary nerve through the *quadrilateral space* bounded above by the teres minor and subscapularis, below by the teres major, medially by the long head of the triceps brachii, and laterally by the surgical neck of the humerus. It winds round the surgical neck and divides into several branches which enter the deep surface of the deltoideus ; some twigs are also given to the shoulder joint. It anastomoses above with the acromial branch of the thoracoacromial artery, in front with the anterior humeral circumflex artery, and below with the arteria profunda brachii.

**Scapular anastomosis.**—This important arterial anastomosis takes place both on the dorsal and ventral aspects of the scapula—between the branches of the subscapular artery, which arises from the axillary artery, and the transverse scapular and the descending branch of the transverse cervical artery, which are derived from the thyreocervical trunk of the subclavian artery.

### The Brachial Artery (Figs. 226, 227)

The **brachial artery** is the direct continuation of the axillary artery and extends from the lower border of the teres major to a little below the centre of the crease at the bend of the elbow where it divides opposite the upper part of the neck of the radius into the radial and ulnar arteries. It lies at first on the medial side of the humerus but gradually inclines lateralwards and occupies the front of the bone; at the bend of the elbow it is placed midway between the two epicondyles. The artery is superficial throughout the greater part of its course and is slightly overlapped by the coracobrachialis and biceps brachii on its lateral side; at the bend of the elbow however the artery is deeply placed beneath the lacertus fibrosus and lies in the cubital fossa. Two venæ comites accompany the artery, one on either side, and these communicate with each other in front and behind by several short transverse branches.

**Relations.**—*In front* the artery is covered by the skin, superficial and deep fasciæ and at the bend of the elbow by the lacertus fibrosus which lies between it and the median cubital vein; it is crossed by the median nerve at about its middle from the lateral to the medial side. *Behind* it is in relation from above downwards with the long head of the triceps brachii (the radial nerve and arteria profunda brachii intervening), the medial head of the triceps brachii, the coracobrachialis, and brachialis. *Laterally* it is slightly overlapped by the coracobrachialis above and biceps brachii below; the median nerve lies lateral to it in the upper half of the arm. *Medial* to it are the medial antibrachial cutaneous and ulnar nerves on the upper half of the arm and median nerve on the lower half; the basilic vein lies medial to it throughout the whole length of the arm but is separated from the artery by the deep fascia in the lower half of the arm. The median nerve is related to the artery throughout the arm; thus in the upper part it lies lateral to the artery, then crosses superficial to it, and is then placed medial to it.

The **branches** of the brachial artery are: (1) the profunda brachii, (2) the superior ulnar collateral, (3) the inferior ulnar collateral, (4) the nutrient, and (5) the muscular.

The **profunda brachii,** the largest branch of the brachial artery, arises from the medial and back part of that artery below the lower border of the teres major. It runs downwards and backwards in company with the radial nerve between the long and medial heads of the triceps brachii. It then curves around the humerus and lies in the radial sulcus with the radial nerve between

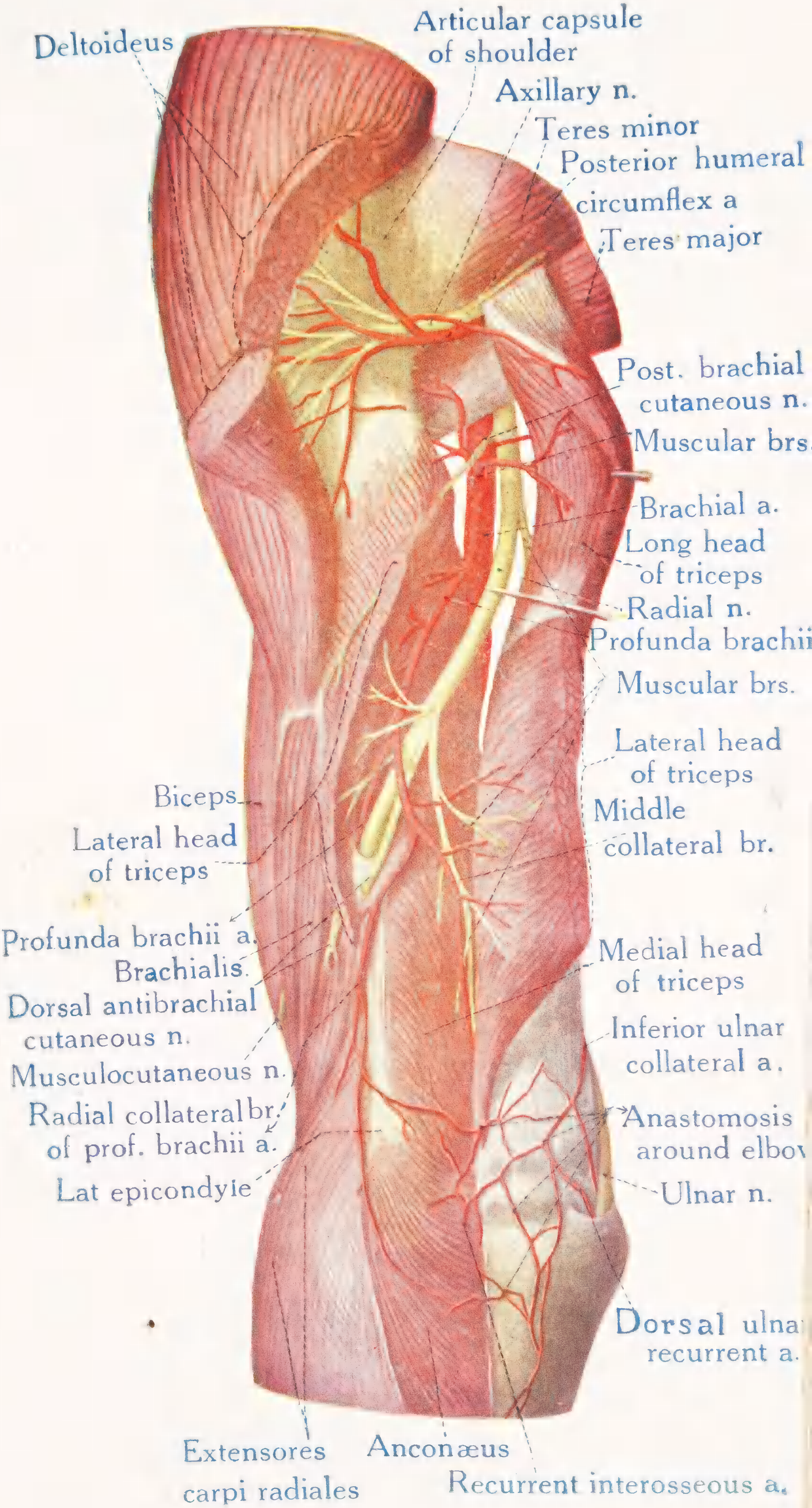


Fig. 227. The arteries of the back of the arm.

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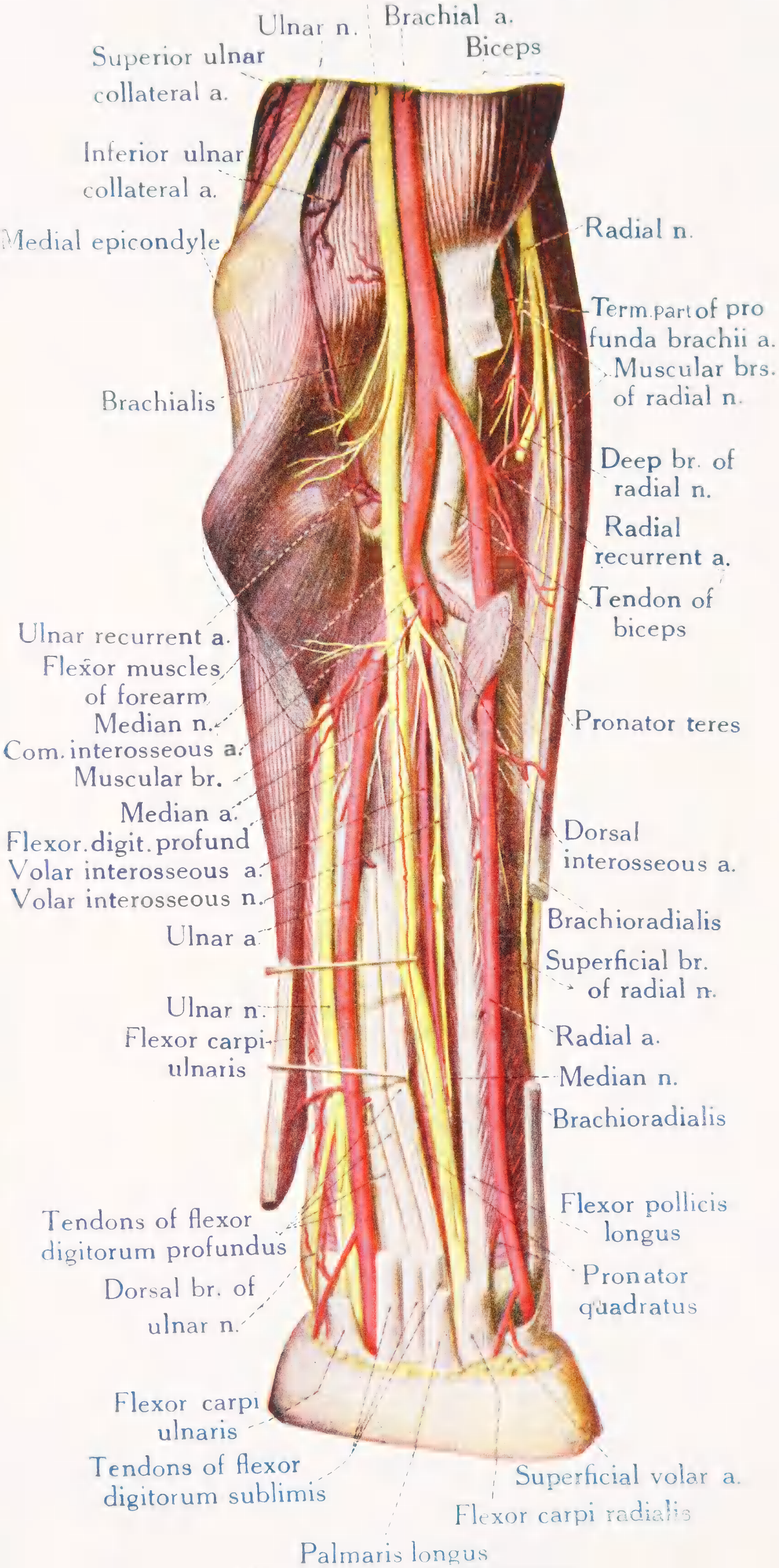
Ulnar n.
Brachial a.
Biceps
Superior ulnar collateral a.
Inferior ulnar collateral a.
Medial epicondyle
Radial n.
Term. part of profunda brachii a.
Muscular brs. of radial n.
Brachialis
Deep br. of radial n.
Radial recurrent a.
Tendon of biceps
Ulnar recurrent a.
Flexor muscles of forearm
Median n.
Com. interosseous a.
Muscular br.
Pronator teres
Median a.
Flexor. digit. profund
Volar interosseous a.
Volar interosseous n.
Dorsal interosseous a.
Brachioradialis
Ulnar a.
Superficial br. of radial n.
Ulnar n.
Flexor carpi ulnaris
Radial a.
Median n.
Brachioradialis
Flexor pollicis longus
Tendons of flexor digitorum profundus
Dorsal br. of ulnar n.
Pronator quadratus
Flexor carpi ulnaris
Tendons of flexor digitorum sublimis
Superficial volar a.
Flexor carpi radialis
Palmaris longus

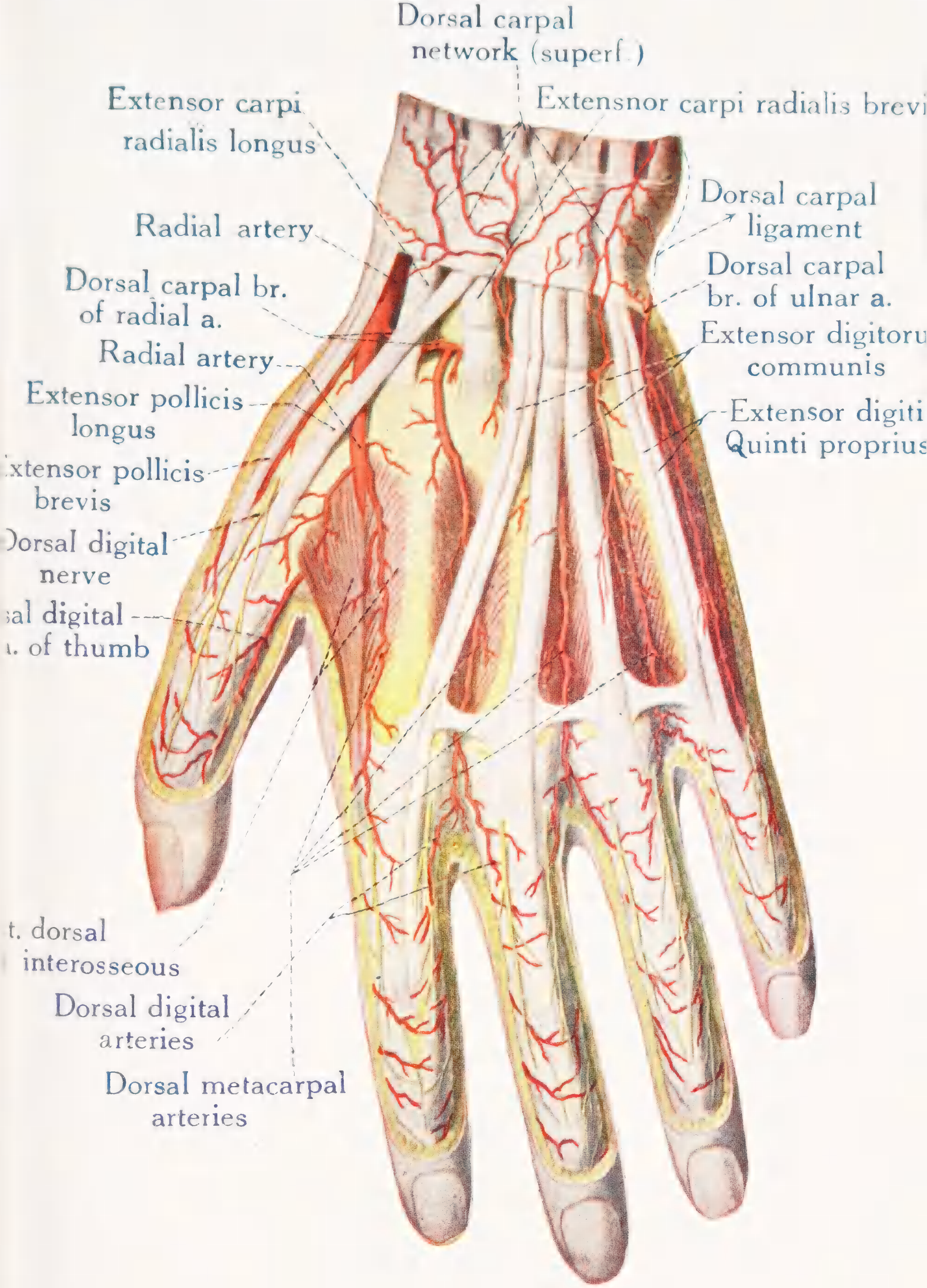
Dorsal carpal network (superf.)
Extensor carpi radialis longus
Extensnor carpi radialis brevi
Radial artery
Dorsal carpal ligament
Dorsal carpal br. of radial a.
Dorsal carpal br. of ulnar a.
Radial artery
Extensor digitoru communis
Extensor pollicis longus
Extensor digiti Quinti proprius
xtensor pollicis brevis
)orsal digital nerve
al digital . of thumb
t. dorsal interosseous
Dorsal digital arteries
Dorsal metacarpal arteries

Fig. 229.—The arteries of the dorsum of the wrist and hand.

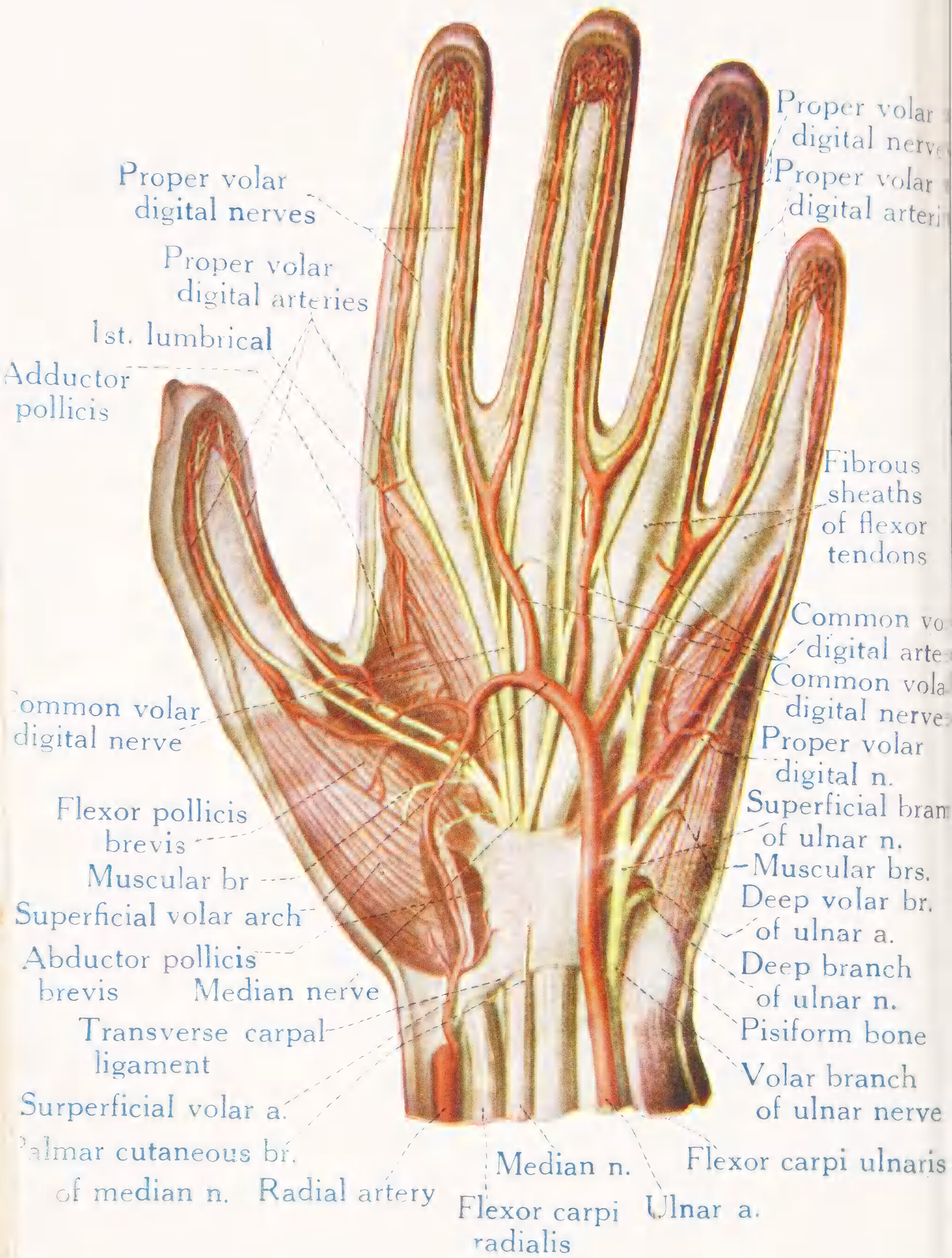

Fig. 230.—The arteries of the front of the wrist and palm. Superficial dissection.

To face p. 405.

the medial and lateral heads of the muscle. Reaching the lateral supracondyloid ridge of the humerus it pierces the lateral intermuscular septum, appears in the front of the arm and is now known as the *terminal part* or *anterior branch* of the profunda brachii. The terminal part accompanies the radial nerve and descends between the brachialis medially and the brachioradialis laterally to the front of the lateral epicondyle where it anastomoses with the radial recurrent artery. **Branches.**—(1) The *radial collateral branch,* also known as the *posterior branch* of the profunda brachii, issues before the parent trunk pierces the lateral intermuscular septum; it runs downwards along the back aspect of the septum to the back part of the lateral epicondyle of the humerus and anastomoses with the interosseous recurrent artery; it forms an anastomotic arch with the inferior ulnar collateral artery above the olecranon fossa. (2) *Muscular branches* are given to the deltoideus and to other muscles between which it passes. (3) A *nutrient artery* enters the humerus usually behind the deltoid tuberosity. (4) The *middle collateral branch* descends through the medial head of the triceps in company with the nerve to the anconæus and joins the anastomotic arch above the olecranon. (5) A *branch* ascends between the long and lateral heads of the triceps brachii and anastomoses with the posterior humeral circumflex artery.

The **superior ulnar collateral artery** (inferior profunda artery) arises from the brachial near the middle of the arm, passes downwards and medialwards in company with the ulnar nerve and pierces the medial intermuscular septum. It then descends behind the septum accompanied by the ulnar nerve and lying upon the medial head of the triceps brachii to the back of the medial epicondyle where it anastomoses with the dorsal ulnar recurrent and inferior ulnar collateral arteries. It gives off an *anterior branch* which anastomoses with the volar ulnar recurrent artery in front of the medial epicondyle.

The **inferior ulnar collateral artery** (anastomotica magna) arises about two inches above the termination of the brachial. It passes medialwards upon the brachialis and divides into two branches, an anterior and a posterior. The *anterior branch* descends in front of the medial epicondyle of the humerus to anastomose with the volar ulnar recurrent artery. The *posterior branch* pierces the medial intermuscular septum and reaches the back aspect of the arm. Here it gives off a branch which passes downwards to anastomose with the dorsal ulnar recurrent artery behind the medial epicondyle of the humerus. It then turns laterally between the posterior surface of the humerus and the medial head of the triceps brachii and forms an arterial arch with the radial collateral branch of the arteria profunda brachii above the olecranon fossa.

The **nutrient artery** arises from the middle of the brachial and enters the nutrient foramen of the humerus near the insertion of the coracobrachialis.

The **muscular branches**, about four or five in number, arise from the lateral side of the brachial artery and supply the muscles on the front of the arm.

**Arterial anastomosis around the elbow joint.**—This anastomosis may be divided into five distinct sets according to their position: of these anastomoses four are vertical and situated symmetrically in front of and behind both the epicondyles of the humerus; the fifth is a transverse arterial arch above the olecranon fossa of the humerus. *In front* of the medial epicondyle—the anastomosing arteries are the volar ulnar recurrent artery and the anterior branches of the superior and inferior ulnar collateral arteries; *behind* the medial epicondyle—the dorsal ulnar recurrent and the superior and inferior ulnar collateral arteries inosculate. *In front* of the lateral epicondyle—the anastomosing arteries are the radial recurrent and the termination of the arteria profunda brachii; *behind* the lateral epicondyle—the interosseous recurrent, the inferior ulnar collateral, and the radial collateral branch of the arteria profunda brachii inosculate. The arterial arch which is seen above the olecranon fossa is formed by the inosculation of the inferior ulnar collateral artery with the interosseous recurrent and dorsal ulnar recurrent arteries; the arch is joined from above by the middle collateral branch of profunda brachii artery.

## The Radial Artery

The **radial artery** (Figs. 228 to 231), the smaller of the two terminal branches of the brachial, appears as the direct continuation of the brachial. It begins in the cubital fossa opposite the neck of the radius and runs downwards and slightly lateralwards along the radial side of the volar aspect of the forearm to the styloid process of the radius—this constitutes the *first part* of the artery or the portion of the *radial artery lying in the forearm*.. The *second part* of the artery or the *radial artery at the wrist* winds backwards below the styloid process of the radius to the back of the wrist and runs downwards to reach the proximal end of the first interosseous space. The *third part* of the artery or the *radial artery in the palm of the hand* extends medialwards from the proximal end of the first interosseous space to the point where it joins the deep branch of the ulnar artery in the palm of the hand to form the deep volar arch. The radial artery is accompanied by a pair of venæ comites which are connected together by several transverse branches.

The **first part** of the radial artery lies in the forearm and is placed to the medial side of the body of the radius above but in front of the bone below. *In front* it is covered in the upper half by the brachioradialis and in the lower half of its course it is covered by the skin and superficial and deep fasciæ. *Behind* it rests from above downwards upon the tendon of the biceps brachii, the supinator, the insertion of the pronator teres, the radial portion of the flexor digitorum sublimis, the flexor pollicis longus, the pronator quadratus, and the lower end of the radius. *Lateral* to it is the brachioradialis; the superficial branch of the radial nerve lies laterally quite close to it in the middle third of the forearm. *Medial* to it is the pronator teres in the upper third of the forearm and the flexor carpi radialis in the rest of its extent. Owing to the superficial position of the radial artery in front of the lower end of the radius the pulse is felt at this situation.

The **branches of the first part** of the radial artery are: (1) the radial recurrent, (2) the volar carpal, (3) the superficial volar, and (4) the muscular.

The **radial recurrent artery** arises from the lateral side of the radial close to its commencement. It runs lateralwards upon the supinator and passing between the superficial and deep divisions of the radial nerve reaches the lateral epicondyle of the humerus where it anastomoses with the terminal part of the arteria profunda brachii. It supplies the neighbouring muscles.

The **volar carpal branch** (anterior radial carpal) arises opposite the lower border of the pronator quadratus, passes medialwards beneath the flexor tendons and anastomoses with the volar carpal branch of the ulnar artery to form the **volar carpal network**. This network is joined from above by a branch of the volar interosseous artery and from below by the recurrent branches of the deep volar arch. Branches proceed from this network to supply the wrist joint and carpal articulations.

The **superficial volar branch** arises from the radial artery just before this vessel winds round the wrist and runs downwards to the palm where it passes either superficial to or through the short muscles of the thumb. It may end in those muscles or may continue its course and join the termination of the ulnar artery to complete the superficial volar arch.

The **muscular branches** are several twigs which supply the muscles on the lateral side of the volar aspect of the forearm.

The **second part** of the radial artery winds backwards below the styloid process of the radius. It lies successively upon the radial collateral ligament of the wrist joint, on the navicular, and on the greater multangular bone. Reaching the proximal end of the first interosseous space it dips between the two heads of the first dorsal interosseous muscle and gains the palm. It is crossed successively by the abductor pollicis longus, extensor pollicis brevis, and extensor pollicis longus; superficially it is covered by skin and by fascia which contains cephalic vein, and filaments of the superficial branch of the radial nerve.

The **branches of** the second part of the radial artery are: (1) dorsales pollicis (2 dorsalis indicis radialis, (3) first dorsal metacarpal, and (4) dorsal carpal.

The **dorsales pollicis** are two small arteries which arise from the radial artery opposite the base of the first metacarpal bone and are distributed to the borders of the dorsal aspect of the thumb.

The **dorsalis indicis radialis** arises a little above the point where the radial artery dips in between the two heads of the first dorsal interosseous muscle and is distributed to the dorsal aspect of the lateral border of the index finger.

The **first dorsal metacarpal artery** runs over the dorsal aspect of the second dorsal interosseous muscle and divides into two dorsal digital branches which supply the adjacent sides of the index and middle fingers.

The **dorsal carpal branch** arises from the radial as it passes under the abductor pollicis longus. It passes medialwards across the dorsum of the carpus under cover of the extensor tendons and anastomoses with the dorsal carpal branch of the ulnar artery to complete the **dorsal carpal network.** This network receives above the terminations of the volar and dorsal interosseous arteries and gives off two slender arteries the *second* and *third dorsal metacarpal arteries* which run over the dorsal aspects of the third and fourth dorsal interosseous muscles. Reaching the head of the metacarpal bone each dorsal metacarpal artery divides into two *dorsal digital branches:* those of the second supply the contiguous sides of the middle and ring fingers; those of the third supply the contiguous sides of the ring and little fingers. Each dorsal metacarpal artery is joined to the deep volar arch by its superior perforating branch which emerges at the proximal part of the interosseous space; each also communicates with a common volar digital branch of the superficial volar arch by an inferior perforating branch which emerges at distal part of the interosseous space.

The **third part** of the radial artery begins from the proximal end of the first interosseous space and enters the palm passing between the two heads of the first dorsal interosseous muscle. It then runs medialwards between the oblique and the transverse heads of the adductor pollicis and continues its course in a slightly curved manner across the bases of the second, third and fourth metacarpal bones and interosseous muscles and anastomoses, at the base of the fifth metacarpal bone with the deep branch of the ulnar artery to complete the deep volar arch.

The **branches** of the third part of the radial artery are: (1) the princeps pollicis, and (2) the volaris indicis radialis.

The **arteria princeps pollicis** arises from the radial artery when it enters the palm. It passes downwards between the oblique part of the adductor pollicis and first dorsal interosseous muscle and along the medial side of the first metacarpal bone under cover of the tendon of the flexor pollicis longus; opposite the metacarpophalangeal joint it divides into two collateral branches which are distributed to the sides of the thumb. At the end of the thumb these branches form an anastomosis which supplies the subcutaneous tissue of the thumb.

The **arteria volaris indicis radialis** may have a common origin with the preceding artery. It passes downwards between the first dorsal interosseous muscle and the transverse part of the adductor pollicis and is distributed to the radial side of the volar aspect of the index finger in a way similar to that of the proper volar digital arteries. At the lower border of the adductor pollicis it often gives off a branch which communicates with the superficial volar arch.

The **deep volar arch** (deep palmar arch) (Fig. 231) is formed by the terminal part of the radial artery anastomosing with the deep volar branch of the ulnar artery. It extends from the base of the fifth metacarpal bone to the proximal end of the first interosseous space, describing a slight curve with the convexity directed towards the fingers. It is about half an inch nearer to the wrist than the superficial volar arch. It lies under cover of the superficial and deep flexor tendons, the lumbricales, and the adductor pollicis. It rests upon the bases of the metacarpal bones and interossei. Alongside it is the deep branch of the ulnar nerve which lies in its concavity.

The **branches** of the deep volar arch are : (1) the perforating, (2) the recurrent, (3) the articular, and (4) the volar metacarpal.

The **perforating branches** are three in number which pass backwards from the arch through the proximal parts of the second, third and fourth interosseous spaces and anastomose with the dorsal metacarpal arteries.

The **recurrent branches** are minute twigs which pass proximally from the concavity of the arch in front of the carpus, anastomose with the volar carpal branches of the radial and ulnar arteries and form a network called the **volar carpal network**.

The **articular twigs** supply the adjacent joints.

The **volar metacarpal arteries** are three in number, which come off from the convexity of the deep volar arch. They proceed distally on the interosseous muscles of the second, third and fourth interosseous spaces and anastomose with the corresponding common volar digital arteries before their bifurcation.

## The Ulnar Artery

The **ulnar artery** (Figs. 228, 230, 231) is the larger of the two terminal branches of the brachial. It begins in the cubital fossa opposite the neck of the radius and runs at first *obliquely*, downwards and medialwards and reaching the ulnar side of the forearm, runs *vertically* downwards to the medial end of the upper margin of the transverse carpal ligament—this constitutes the *first part* of the artery or the *portion of the artery lying in the forearm.* The *second part* of the ulnar artery or the *ulnar artery at the wrist* lies over the transverse carpal ligament, extending from its proximal to the distal margin. The *third part* of the ulnar artery or the *artery in the palm* begins at the distal margin of the transverse carpal ligament and lies in the palm. The ulnar artery is accompanied by a pair of venæ comites.

**Relations of the first part.**—The first part of the ulnar artery is subdivided into an oblique portion and a vertical portion.

*Relations of the proximal oblique portion.*—It is deeply placed being covered *in front* by the pronator teres, the flexor carpi radialis, palmaris longus, and flexor digitorum sublimis; the median nerve crosses it from the medial to the lateral side, the ulnar head of the pronator teres intervening between them; the ulnar nerve is not in immediate relation with the oblique portion of the artery but gains its medial side at the commencement of its vertical portion. *Behind* it rests upon the brachialis and flexor digitorum profundus.

*Relations of the distal vertical portion.*—*In front* it is covered by the flexor carpi ulnaris above, but lower down for a short distance above the wrist it is superficial being covered by the skin, the superficial and deep fasciæ. The palmar cutaneous branch of the ulnar nerve descends in front of the artery a little above the wrist. *Behind* it rests upon the flexor digitorum profundus. *Medial* to it is the ulnar nerve which lies close to it on the lower two thirds of the forearm. The tendon of the flexor carpi ulnars also lies medial to it for a short distance above the wrist and serves as a useful guide to the artery. *Lateral* to it is the flexor digitorum sublimis in the lower two thirds of the forearm.

The **branches of the first part** of the ulnar artery are: (1) muscular, (2) volar ulnar recurrent, (3) dorsal ulnar recurrent, and (4) common interosseous.

The **muscular branches** supply the muscles on the ulnar side of the forearm.

The **volar ulnar recurrent artery** arises in the cubital fossa and passes upwards under cover of the pronator teres and anastomoses with the superior and inferior ulnar collateral arteries in front of the medial epicondyle of the humerus.

The **dorsal ulnar recurrent artery** is larger than the volar and arises either a little below the latter or as a common trunk with that branch. It passes medialwards beneath the flexor digitorum sublimis and then runs along the interval between the medial epicondyle of the humerus and olecranon. Finally it ascends between the two heads of the flexor carpi ulnaris in company with the ulnar nerve and anastomoses with the superior and inferior ulnar collateral arteries and the interosseous recurrent artery. It gives branches to the adjacent muscles and to the elbow joint.

The **common interosseous artery** is a short thick trunk about ½ inch long and arises below the preceding branch. It passes backwards to reach the upper border of the interosseous membrane of the forearm where it divides into the volar and dorsal interosseous arteries.

The **volar interosseous artery** runs downwards in front of the volar surface of the interosseous membrane in company with the volar interosseous branch of the median nerve, lying between the flexor pollicis longus laterally and flexor digitorum profundus medially—the adjacent margins of the two muscles overlap the artery. Reaching the upper margin of the pronator quadratus it perforates the interosseous membrane and runs on the dorsal surface of the membrane anastomosing with the dorsal interosseous artery. Descending further on the dorsum of the wrist in the groove for the tendons of the extensor digitorum communis and extensor indicis proprius it ends in the dorsal carpal network. It gives off the following *branches*: (1) *muscular* which supply the neighbouring muscles; (2) *nutrient* to the radius and ulna; (3) *median artery*, a long slender branch, which runs with the median nerve and supplies it and when of large size descends into the palm and enters into the formation of the superficial volar arch; (5) *volar communicating branch* which issues before the artery pierces the interosseous membrane and descends under cover of the pronator quadratus to end in the volar carpal network.

The **dorsal interosseous artery** is smaller than the volar interosseous. It runs backwards in the interval between the upper border of the antibrachial interosseous membrane and the oblique cord and, on the dorsum of the forearm, appears between the supinator and abductor pollicis longus where it is accompanied by the deep branch of the radial nerve. It then descends between the superficial and deep groups of muscles to the dorsum of the wrist and anastomoses with the dorsal carpal network. The *branches* given off from it are: (1) the *interosseous recurrent artery*, which arises at the lower border of the supinator and runs upwards between this muscle and anconæus to the interval between the olecranon and lateral epicondyle of the humgus to anastomose with the radial collateral branch of the arteria profunda brachii and the inferior ulnar collateral artery; (2) *muscular branches* which supply the adjacent muscles.

**Relations of the second part of the ulnar artery.**—The second part of the ulnar artery lies on the transverse carpal ligament. *In front* it is covered by the integument and volar carpal ligament. *Behind* it, is the transverse carpal ligament. *Medial* to it are the ulnar nerve and pisiform bone. *Lateral* to it is the hamulus of the hamate bone.

The **branches** of the second part of the ulnar artery are: (1) the volar carpal, and (2) the dorsal carpal.

The **volar carpal branch** (anterior carpal) runs lateralwards in front of the carpus beneath the flexor tendons and anastomoses with the volar carpal branch of the radial to form the volar carpal network.

The **dorsal carpal branch** arises above the pisiform bone and passes backwards beneath the tendon of the extensor carpi ulnaris to the dorsum of the wrist where it anastomoses with the dorsal carpal branch of the radial artery to form the dorsal carpal network. It gives off a branch which runs along the medial side of the dorsal surface of the little finger and corresponds to a dorsal digital artery.

The **third part of the ulnar artery** lies in the palm and forms the superficial volar arch. It descends under cover of the palmaris brevis and proceeding for a short distance towards the cleft between the fourth and fifth fingers it turns lateralwards across the palm describing an arch, called the **superficial volar arch** (Fig. 239), the convexity of which is towards the fingers. The arch is completed by anastomosis with one of the branches of the radial artery, viz., either with the superficial volar artery, or arteria volaris indicis radialis, or arteria princeps pollicis. Sometimes the arch is completed by the arteria comes nervi mediana ; occasionally the arch is not completed laterally by any anastomosis when it terminates in the muscles of the thenar eminence. **Relations.**—The arch is covered *in front* by the palmaris brevis, the central portion of the palmar aponeurosis. *Behind* it rests upon the superficial flexor tendons, lumbricales, flexor digiti quinti brevis, opponens digiti quinti, and the digital branches of the median nerve.

**Branches.**—The superficial volar arch gives off four volar common digital arteries.

The **volar common digital arteries** arise from the convexity of the arch. The most medial runs along the medial border of the little finger in company with the common digital branch of the ulnar nerve. The other three pass along the middle of the medial three interosseous spaces, lying beneath the common digital nerves and are joined by the corresponding volar metacarpal branches of the deep volar arch ; each of these three bifurcates into *proper volar digital arteries* which pass along the contiguous sides of the fingers beneath the digital nerves. The two proper digital arteries which run along the sides of a finger anastomose with each other forming an arch near the termination of the last phalanx. From this arch minute twigs are supplied by the subcutaneous tissue of the finger tip and the nail bed. They also communicate by dorsal branches with the dorsal digital arteries.

As the ulnar artery lies on the transverse carpal ligament and usually at its lower margin, it gives off the **deep volar branch** which passes deeply into the palm, with the deep division of the ulnar nerve, between the abductor digiti quinti and flexor digiti quinti brevis and through the fibres of the opponens digiti quinti. It then joins the termination of the radial artery to complete the deep volar arch.

## THE DESCENDING AORTA (Fig. 232)

The **thoracic aorta** is the thoracic portion of the descending aorta. It begins at the lower border of the fourth thoracic vertebra on its left side and descending through the posterior mediastinum ends in the aortic opening of the diaphragm opposite the lower border of the twelfth thoracic vertebra ; thence it is continued downwards as the abdominal aorta. At its commencement it lies to the left of the vertebral column but gradually approaches the median line. *In front* it has the root of the left lung, the pericardium, the œsophagus and the crura of the dia-

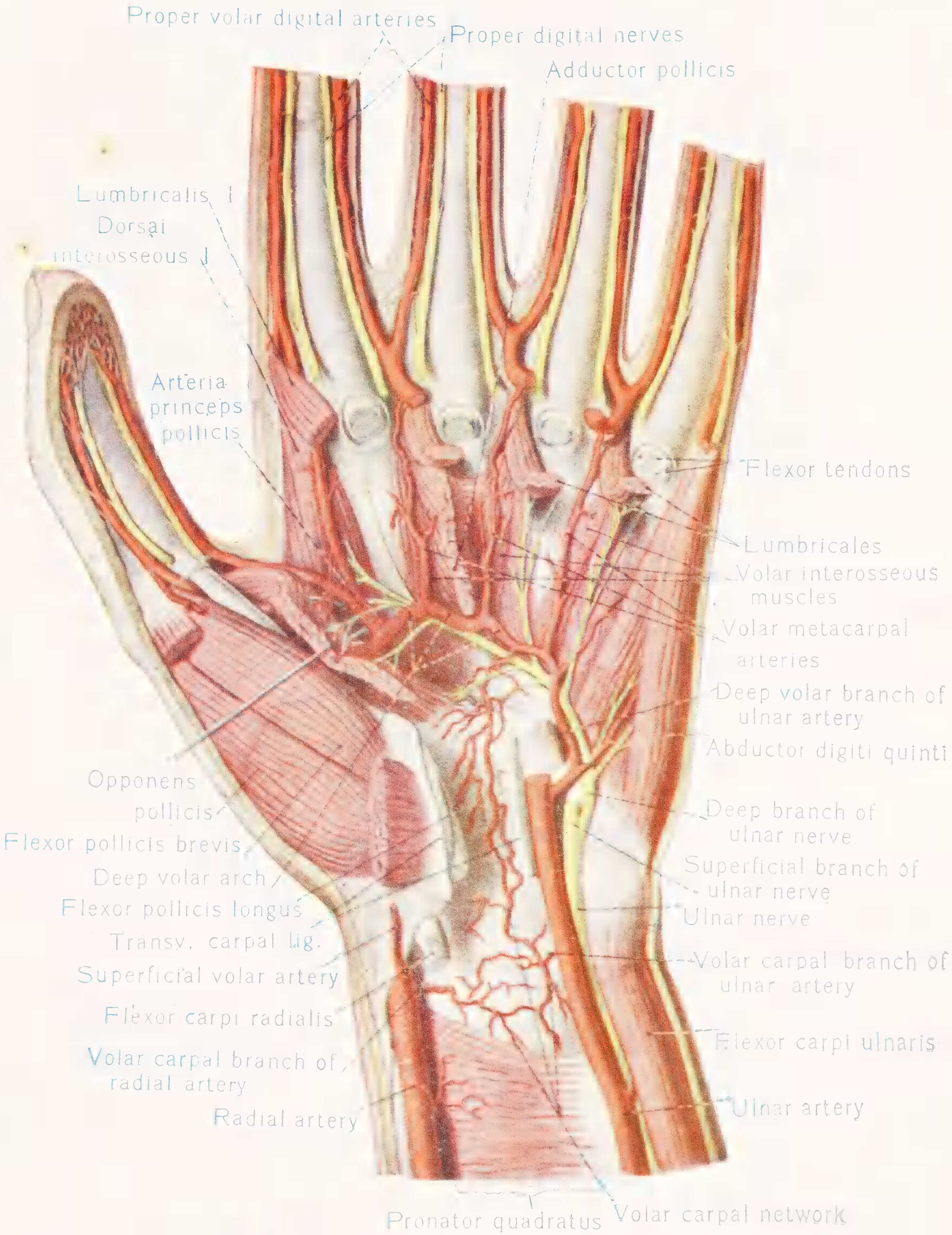

Fig. 231.—The arteries of the front of the wrist and palm. Deep dissection.

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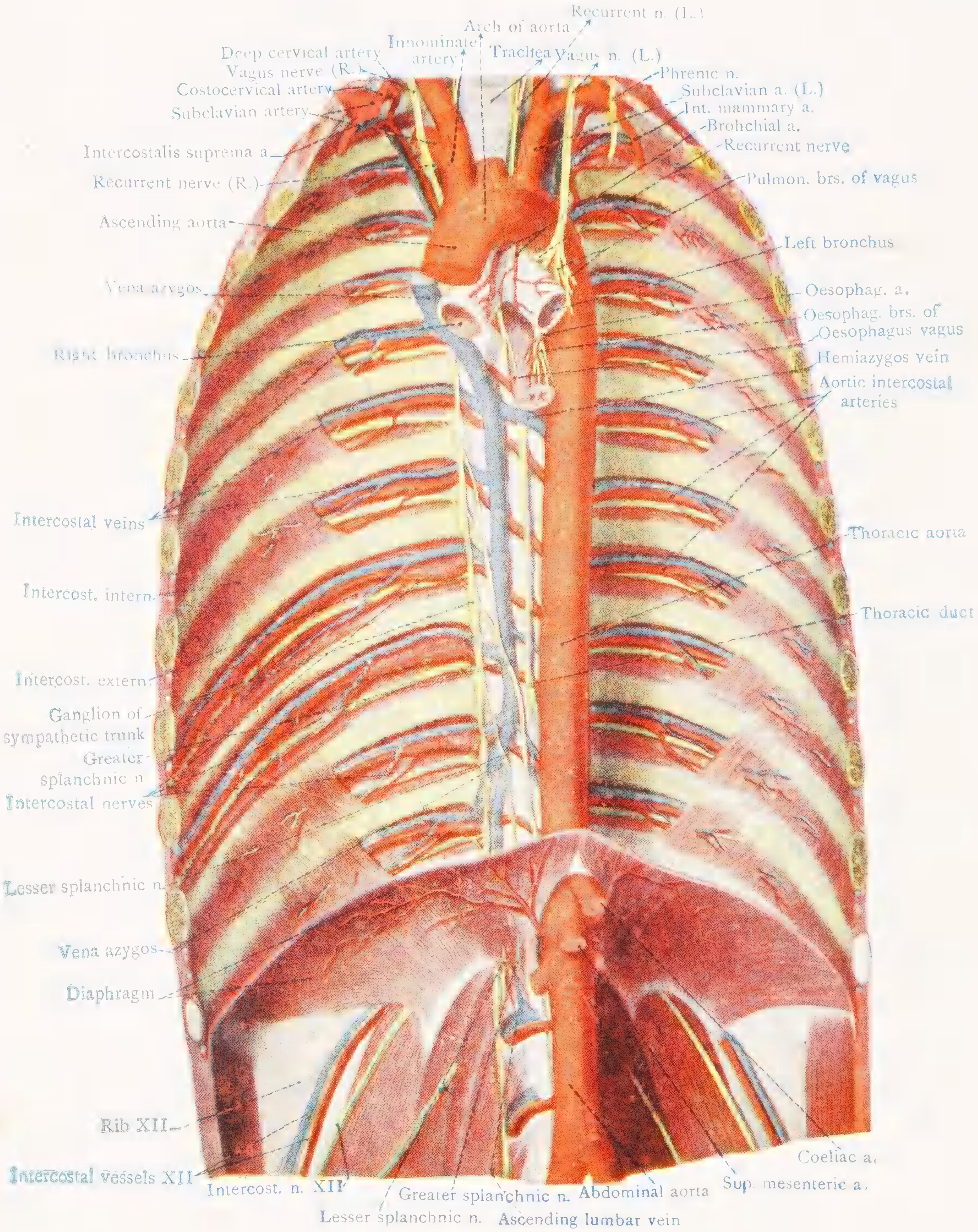

Fig. 232.—The arch of the aorta and the descending aorta.

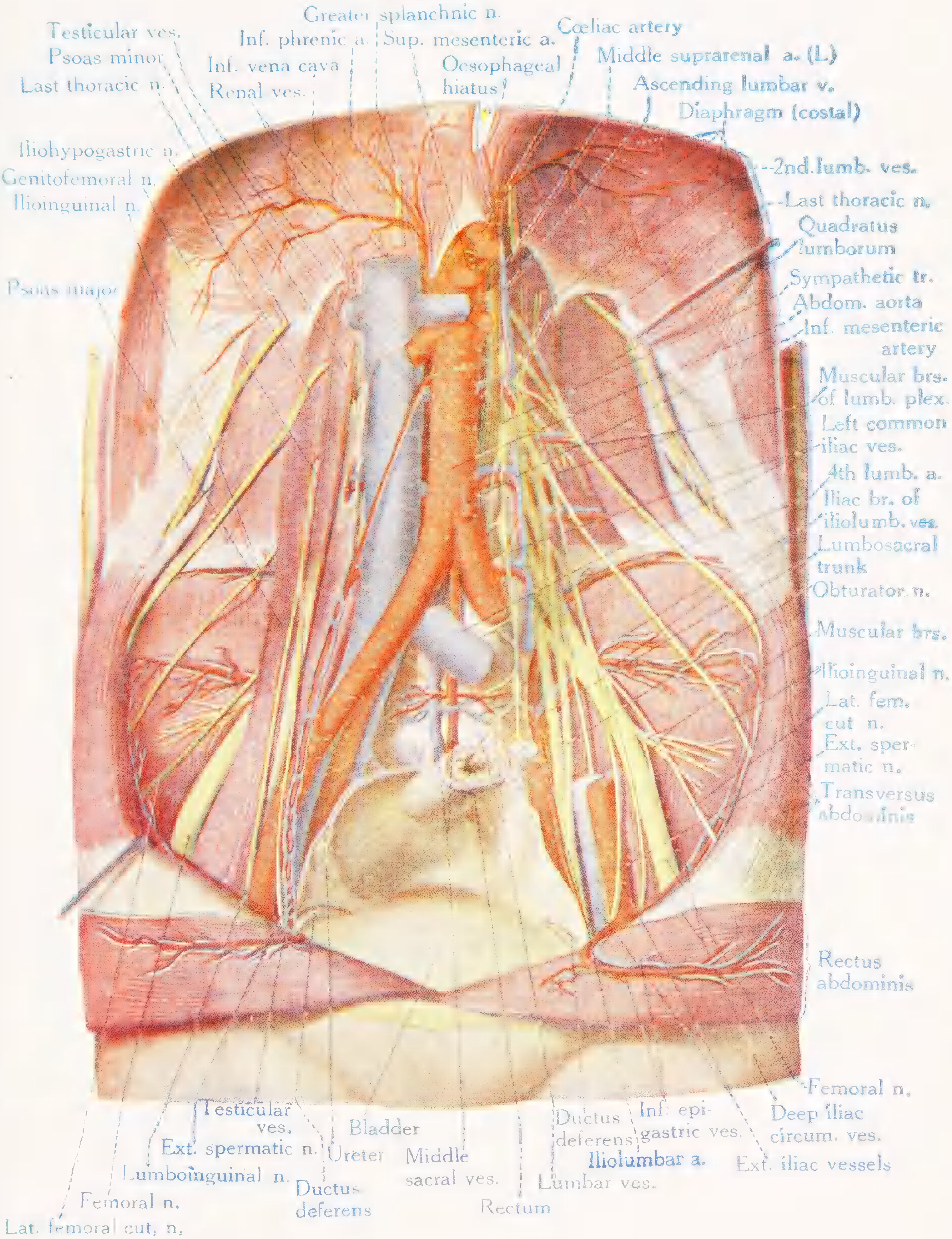

Fig. 233.—The abdominal aorta and its branches

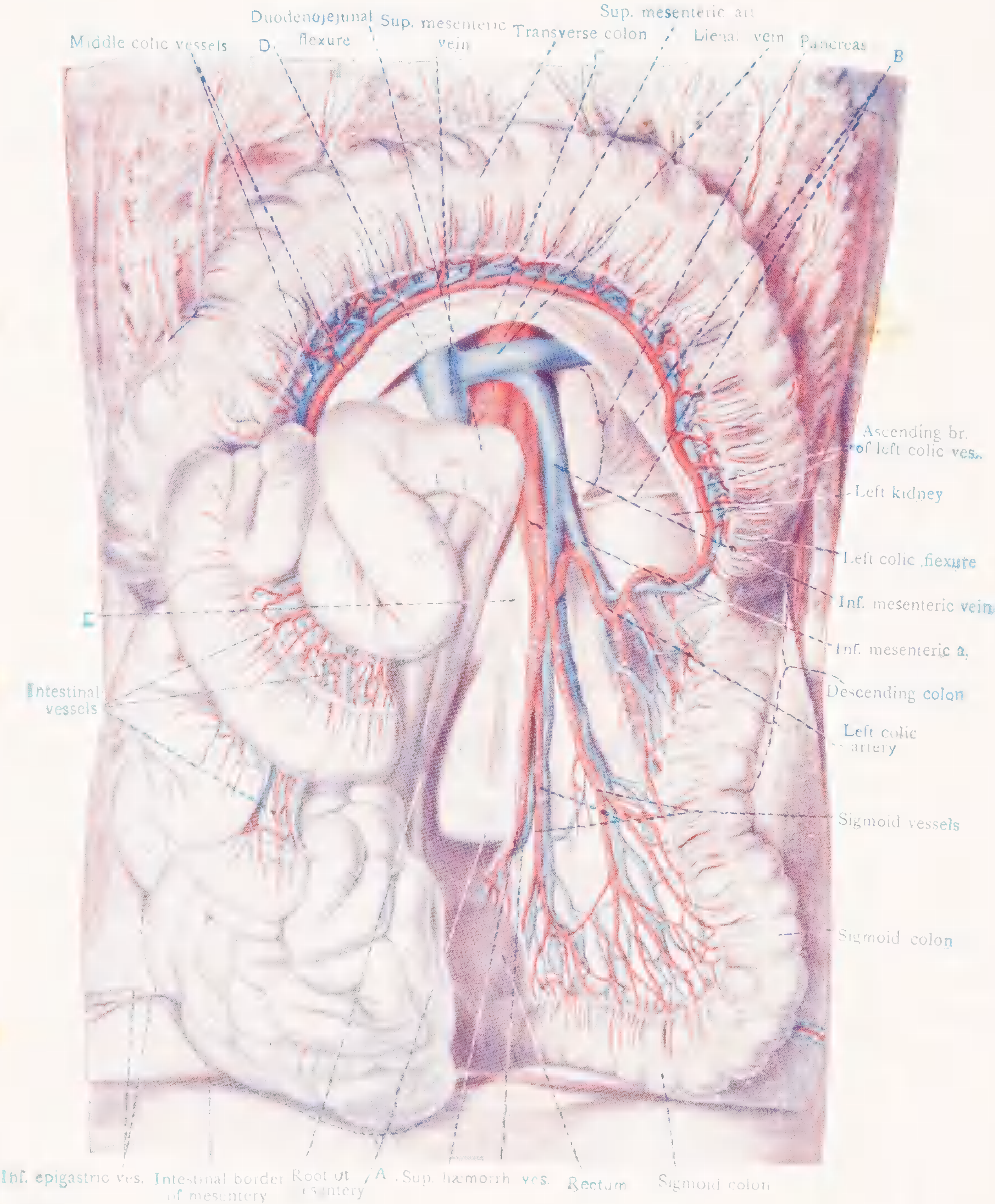

Fig. 235.—The inferior mesenteric artery and its branches.

A & E—Peritoneum of mesentery. B, C & D—Transverse mesocolon.

phragm, in that order from above downwards. *Behind* it are the vertebral column, the hemiazygos and accessory hemiazygos veins. On its *right side* are the œsophagus (above), the azygos vein and the thoracic duct. On the *left side* it has the mediastinal pleura, the left lung and the œsophagus (below). The œsophagus has therefore a threefold relation to the thoracic aorta. At first it lies to the right of the artery, then lies in front of the artery, and finally lies to its left.

The **branches** of the thoracic aorta are divided into the visceral and parietal. The *visceral branches* are the bronchial, pericardial, and œsophageal. The *parietal branches* are the costal, subcostal, superior phrenic, and mediastinal.

The **bronchial arteries** are the nutrient vessels of the lungs. As the rule there are two left bronchial arteries and one right bronchial artery. The *right bronchial artery* arises either from the first aortic intercostal artery or conjointly with the upper left bronchial artery from the front of the thoracic aorta. It runs behind the right bronchus, divides and subdivides and is distributed to the bronchial tubes, the cellular tissue of the lung, and the bronchial lymph glands. The *left bronchial arteries* arise from the thoracic aorta, run behind the left bronchus and have a distribution like that of the right bronchial artery.

The **pericardial branches** are a few twigs distributed to the back part of the pericardium.

The **œsophageal branches** are four or five in number and ramify in the wall of the œsophagus and anastomose above with œsophageal branches of the inferior thyreoid artery and below with the œsophageal branches of the left gastric artery.

**Intercostal arteries.**—There are eleven pairs of intercostal arteries. In the first two intercostal spaces they are derived from the arteria intercostalis suprema which springs from the costocervical branch of the subclavian artery; while in the nine lower intercostal spaces they (the *nine pairs of aortic intercostal arteries*) are derived from the back of the thoracic aorta. In consequence of the thoracic aorta lying to the left of the median line of the vertebral column the right aortic intercostal arteries are longer than the left. The *right aortic intercostal arteries* cross the bodies of the thoracic vertebræ behind the œsophagus, the thoracic duct and the azygos vein and lie under cover of the parietal pleura. The *left aortic intercostal arteries* pass backwards on the sides of the thoracic vertebræ and lie under cover of the pleura; the lower arteries are crossed by the hemiazygos and accessory hemiazygos veins. From the sides of the bodies of the thoracic vertebræ the further course of the intercostal arteries on both sides is almost the same. They pass lateralwards behind the parietal pleura and the sympathetic nerve trunk and enter the intercostal spaces. Up to the angle of the rib each artery at first lies on the posterior intercostal membrane covered by the parietal pleura and then between the internal and external intercostal muscles in the costal groove. In the costal groove the companion vein lies above and the intercostal nerve lies below. Midway between the vertebral column and the sternum each intercostal artery gives off a *collateral branch* which descends to the upper border of the rib below. The main artery continues its course along the lower border of the rib above and its collateral branch along the upper border of the rib below. Both of these pass medialwards between the external and internal intercostal muscles towards the sternum to anastomose with the two anterior intercostal branches of the internal mammary artery in the six upper intercostal spaces and with those of the musculophrenic artery in the seventh, eighth and ninth spaces. The aortic intercostal arteries of the tenth and eleventh intercostal spaces pass medialwards into the anterior abdominal wall between the internal oblique and transversus abdominis. They run in company with the corresponding nerves and anastomose with the superior epigastric, subcostal and lumbar arteries.

The **branches** of the intercostal artery are : (1) posterior, (2) collateral, (3) muscular, (4) lateral cutaneous.

The *posterior branch* arises near the posterior extremity of an intercostal space and runs in company with the posterior primary division of the corresponding spinal nerve. Near the adjacent transverse process it divides into a *medial cutaneous* and a *lateral cutaneous branch* which supply the muscles and skin of the back. Before the division it gives off a *spinal branch* which enters the vertebral canal and supplies the medulla spinalis and its membranes. The *collateral branch* has been described above. The *muscular branches* supply the adjacent muscles.

The *lateral cutaneous branch* accompanies the lateral cutaneous branch of the corresponding intercostal nerve and ends in the skin. The upper three or four aortic intercostal arteries supply branches to the mammary gland.

The **subcostal arteries** are two in number, one on each side. They are in a line with the intercostal arteries and arise from the back part of the thoracic aorta. Each artery passes lateralwards below the twelfth rib accompanied by the twelfth thoracic nerve. It next runs beneath the lateral lumbocostal arch, reaches the abdomen and lies between the kidney in front and quadratus lumborum behind. Piercing the posterior aponeurosis of the transversus it runs forwards between this muscle and the internal oblique and anastomoses with the last intercostal, first lumbar and superior epigastric arteries. Each gives off a posterior branch which has a course like that of an aortic intercostal.

The **superior phrenic** are small branches which issue from the lower portion of the thoracic aorta and supply the thoracic surface of the diaphragm.

The **mediastiastinal** are numerous small branches which supply the lymph glands of the posterior mediastinal space.

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## The Abdominal Aorta

The **abdominal aorta** (Fig. 233) is the abdominal portion of the descending aorta. It extends from the lower border of the twelfth thoracic vertebra at the aortic opening of the diaphragm to the level of the body of the fourth lumbar vertebra a little to the left of which it divides into the two common iliac arteries. It runs an oblique course for it begins in the median line and ends a little to the left of the median line. Its termination takes place opposite a point below and slightly to the left of the umbilicus and on a level with the highest point of the iliac crest.

**Relations.**—The abdominal aorta lies in relation *in front* with the omental bursa and stomach behind which are the cœliac artery and the cœliac plexus of nerves ; below these with the lienal vein, the pancreas, the left renal vein, the horizontal part of the duodenum, the mesentery proper, the aortic plexus and preaortic lymph glands. *Behind* it are the bodies and intervertebral discs of the lumbar vertebræ, the anterior longitudinal ligament and the left lumbar veins. On its *right side* are the azygos vein, the cisterna chyli, the thoracic duct, the right crus of the diaphragm—the last separates it from the upper part of the inferior vena cava ; its lower part is in contact the inferior vena cava. On the *left side* the left crus of the diaphragm, the left cœliac ganglion and the ascending part of the duodenum are in relation with its upper part while its lower part is in contact with peritoneum and some coils of the small intestine. On either side of the aorta are many lymph glands called the lateral aortic lymph glands.

The **branches of the abdominal aorta** arise in the following order (excluding the lumbar arteries) :—First are the two inferior phrenic arteries which issue from the front of the aorta immediately it enters the abdominal cavity ; next is the single trunk of the cœliac artery ; about a quarter of an inch lower down is the trunk of the superior mesenteric artery ; at the same level as the superior mesenteric are the two middle suprarenal arteries, one from each side of the aorta ; half an inch lower down the right and left renal arteries arise from the sides of the aorta ; below the renal are the two testicular or ovarian arteries, arising from the front of the aorta ; about two inches above the bifurcation of the aorta, the trunk of the inferior mesenteric artery issues ; the single middle sacral artery takes origin from the back part of the aorta a little above its bifurcation ; the lumbar arteries, four in number, on either side, arise from opposite the upper four lumbar vertebræ.

The branches of the abdominal aorta may be classified into three sets : (I) the *visceral*—these are the cœliac, superior mesenteric, middle suprarenal, renal, testicular (in the male), ovarian (in the female), inferior mesenteric ; (II) the *parietal*—the inferior phrenic, lumbar, middle sacral ; (III) the *terminal*—these are the two common iliac arteries.

The **cœliac artery** (cœliac axis) (Fig. 234) is a short thick trunk, about ½ inch in length. It arises from the front of the abdominal aorta just below the aortic hiatus of the diaphragm and above the superior border of the pancreas. It passes horizontally forwards and divides into three branches viz., the left gastric, the hepatic, and the lienal or splenic. *Relations.*—The cœliac artery lies closely surrounded by the cœliac plexus of the sympathetic. It has the omental bursa *in front,* caudate lobe of the liver *above,* upper border of the body of the pancreas and

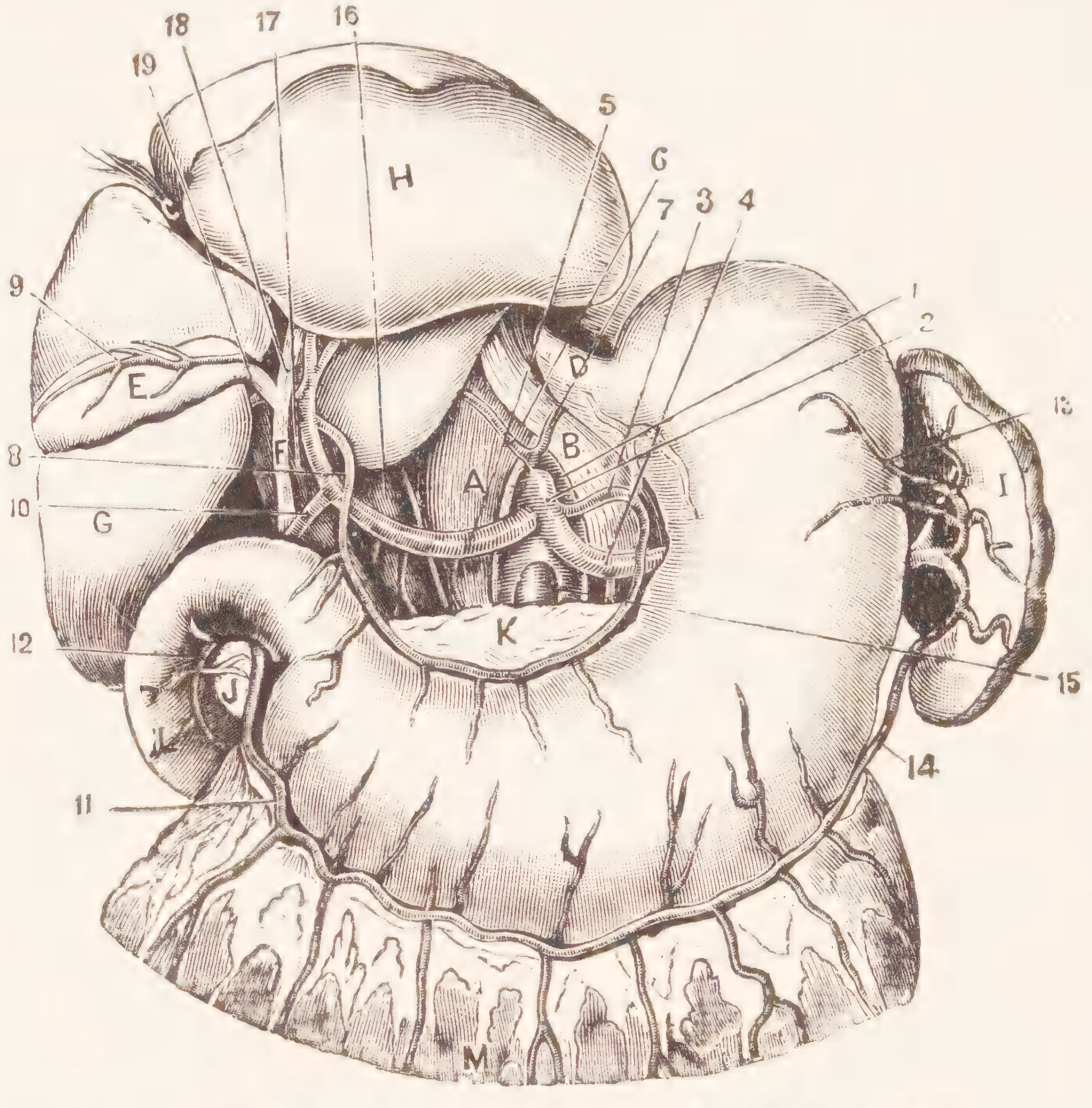

Fig. 234.—The cœliac artery and its branches.

A. Right crus of diaphragm.
B. Left crus of diaphragm.
C. Round ligament of liver.
D. Œsophagus.
E. Gall-bladder.
F. Bile duct.
G. Right lobe of liver.
H. Left lobe of liver.
I. Spleen.
J. Head of pancreas.
K. Body of pancreas.
L. Duodenum.
M. Greater omentum.

1. Abdominal aorta.
2. Cœliac artery.
3. Left gastric artery.
4. Splenic artery.
5. Hepatic artery.
6. Right inferior phrenic artery.
7. Left inferior phrenic artery.
8. Right gastric artery.
9. Cystic artery.
10. Gastro-duodenal artery.
11. Gastro-epiploica dextra.
12. Pancreatico-duodenalis superior.
13. Short gastric branch of lienal artery.
14. Gastro-epiploica sinistra.
15. Superior mesenteric artery.
16. Inferior vena cava.
17. Portal vein.
18. Common hepatic duct.
19. Cystic duct.

lienal vein *below*, the right cœliac ganglion to its *right side*, the left cœliac ganglion to its *left side*.

The **left gastric artery** (gastric or coronary artery) (Fig. 234) passes upwards and to the left behind the omental bursa to the right side of the cardiac orifice of the stomach. Thence it changes its direction and passes along the lesser curvature of the stomach between the two layers of the lesser omentum to anastomose with the right gastric branch of the hepatic artery. Its **branches** are :—(1) *oesophageal*, which are two or three in number and ascend through the œsophageal opening of the diaphragm to anastomose with the œsophageal branches of the thoracic aorta ; (2) *cardiac*, which are distributed to the cardiac end of the stomach and anastomose with the short gastric branches of the lienal artery ; (3) *gastric*, which arise at the lesser curvature of the stomach and supply both surfaces of the viscus.

The **hepatic artery** (Fig. 234) is intermediate in size between the left gastric and the lienal arteries. It passes forwards and to the right along the superior border of the pancreas to the pylorus and forms the lower boundary of the epiploic foramen. Then it ascends between the two layers of the lesser omentum forming the anterior boundary of the same foramen. Here it lies to the left of the bile-duct and in front of the portal vein. Near the porta of the liver it divides into two terminal branches, the right and left hepatic arteries. It is accompanied by a plexus of nerve fibres prolonged from the cœliac plexus. The **branches** of the hepatic artery are : (1) right gastric, (2) gastroduodenal, (3) right hepatic, (4) left hepatic.

(1) The **right gastric artery** (pyloric artery) arises near the pylorus and passes to the left along the lesser curvature of the stomach between the layers of the lesser omentum. It anastomoses with the left gastric artery and gives branches to both surfaces of the stomach.

(2) The **gastroduodenal artery** descends behind the first part of the duodenum and at its lower border divides into two branches, the right gastroepiploic and the superior pancreaticoduodenal arteries. The *right gastroepiploic artery* runs from the right to the left along the greater curvature of the stomach between the layers of the greater omentum and anastomoses with the left gastroepiploic branch of the lienal artery. It gives branches to both surfaces of the stomach above and to the greater omentum below. The *superior pancreaticoduodenal artery* descends between the head of the pancreas and the duodenum, supplies both these organs and anastomoses with the inferior pancreaticoduodenal branch of the superior mesenteric artery.

(3) The **right hepatic artery** passes to the right end of the porta hepatis where it breaks up into branches which enter the substance of the right lobe of the liver and accompany the branches of the portal vein and hepatic duct. It gives off the *cystic branch* which supplies both surfaces of the gall-bladder. (4) The **left hepatic artery** is longer than the right ;

it passes to the left end of the porta hepatis where it breaks up into branches which end in the substance of the left lobe of the liver.

The **lienal artery** (splenic artery) (Figs. 179, 234) is the largest of the three branches of the cœliac artery and is conspicuous for its tortuous course. It proceeds to the left behind the stomach and the omental bursa and along the superior border of the pancreas, crosses the upper end of the left kidney and divides into several branches which enter the hilum of the spleen. It is surrounded by a plexus of nerve filaments derived from the cœliac plexus. It is accompanied by the lienal vein which lies on a lower level. The branches of the lienal artery are: (1) pancreatic, (2) short gastric, (3) left gastroepiploic, and (4) terminal. (1) The *pancreatic branches* arise at intervals along the superior border of the pancreas and enter the gland. One of the branches is larger than the others and arises near the tail of the pancreas. This is called the *pancreatica magna branch*; it passes from the left to the right in the substance of the pancreas above and posterior to the pancreatic duct. (2) The *short gastric branches* (vasa brevia), five to seven in number, arise from the lienal artery or from its terminal branches. They pass to the right between the two layers of the gastrolienal ligament and supply the cardiac end of the stomach, anastomosing with the branches of the left gastric and the left gastroepiploic arteries. (3) The *left gastro-epiploic artery* is directed from left to right along the greater curvature of the stomach between the layers of the greater omentum and anastomoses with the right gastroepiploic artery. It gives off ascending branches which supply both surfaces of the stomach and descending branches which supply the greater omentum. (4) The *terminal branches* of the lienal artery enter the hilum of the spleen and supply the substance of the spleen.

The **superior mesenteric artery** (Fig. 184) supplies the whole of the small intestine, the cæcum, the ascending colon and the right half of the transverse colon. It arises from the abdominal aorta behind the neck of the pancreas and is crossed superficially by the lienal vein. Then it crosses the lower part of the head of the pancreas and the horizontal part of the duodenum and descends between the two layers of the mesentery till it reaches the right iliac fossa—crossing in this part of its course the aorta, inferior vena cava, right ureter and right psoas major. Here it anastomoses with one of its branches, the ileocolic artery, forming an arch the concavity of which is directed towards the right side. It is surrounded by the superior mesenteric plexus of nerves and is accompanied by the superior mesenteric vein which is placed to its right side. The **branches** of the superior mesenteric artery are: (1) inferior pancreaticoduodenal, (2) jejunal and ileal, (3) ileocolic, (4) right colic, and (5) middle colic.

(1) The **inferior pancreaticoduodenal artery** arises from the upper part of the superior mesenteric or sometimes from its first jejunal branch. It passes to the right between the head of the

pancreas and duodenum, supplies both, and anastomoses with the superior pancreaticoduodenal artery.

(2) The **jejunal** and **ileal arteries** (vasa intestini tenuis) are twelve to fifteen in number. They arise from the convexity of the arch and run forwards and downwards between the two layers of the mesentery. Each of them divides into two branches which by their union with the contiguous branches form a series of primary arches. From the convexities of these primary arches small branches are given off which divide and anastomose in a similar manner forming a series of subsidiary arches. Thus a second, third, fourth, or even a fifth series of arches is formed. From the convexity of the most peripheral arches small branches are given off which encircle the intestine beneath its serous coat and thus all parts of the intestinal wall receive an equal arterial supply. The number of subsidiary arterial arches is greater in the ileal part of the mesentery than in the jejunal part.

(3) The **ileocolic artery** arises from the concavity of the superior mesenteric artery. It passes downwards and to the right behind the peritoneum and divides into two branches, a superior and an inferior. The superior branch ascends and anastomoses with the right colic artery. The inferior branch gives off the following branches :—(*a*) *colic* branches which pass upwards on the ascending colon ; (*b*) *anterior* and *posterior caecal* branches which supply the front and back aspects of the cæcum ; (*c*) *appendicular* artery which descends behind the last part of the ileum and passes along the mesentery of the vermiform process to supply that process ; (*d*) *ileal* branch which passes to the left along the ileum and anastomoses with the termination of the superior mesenteric artery.

(4) The **right colic artery** (colica dextra) arises from the concavity of the superior mesenteric artery above the ileocolic or sometimes in common with it. It passes transversely behind the peritoneum and in front of the right psoas major, right ureter, and right testicular or ovarian vessels, towards the ascending colon and divides into an ascending and a descending branch. The former anastomoses with the middle colic and the latter with the superior branch of the ileocolic. From the anastomotic arch twigs pass to the ascending colon.

(5) The **middle colic artery** (colica media) arises from the superior mesenteric artery just below the pancreas. It passes forwards between the two layers of the transverse mesocolon and divides into a right and a left branch. The right branch anastomoses with the ascending branch of the right colic artery and the left branch with the left colic artery. From the anastomotic arch twigs pass to supply the transverse colon. It may be noted that of the branches of the superior mesenteric, the jejunal and ileal arise from the left side, and the rest from the right side.

The **middle suprarenal arteries** (middle capsular arteries) (Fig. 233), two in number, arise from the abdominal aorta, one on either side, opposite the origin of the superior mesenteric artery. They pass lateralwards and slightly upwards to the suprarenal gland and anastomose with the suprarenal branches of the inferior phrenic artery above and of the renal artery below.

The **renal arteries** (Fig. 233) are two short thick branches which arise from the abdominal aorta just below the origin of the superior mesenteric artery. Each artery passes lateralwards to the hilum of the kidney. The *right artery* is longer than the left and passes behind the inferior vena cava, the head of the pancreas, the descending portion of the duodenum, and right renal vein. The *left artery* is placed on a little higher level than the right and passes behind the body of the pancreas. Before entering the hilum of the kidney each artery divides into three or four branches which lie between the renal vein in front and the renal pelvis behind. These branches enter the substance of the kidney between the pyramids. Each renal artery gives off a branch, the *inferior suprarenal artery*, to the suprarenal gland and some twigs to the ureter and to the surrounding cellular tissue.

The **testicular arteries** (internal spermatic arteries) (Fig. 233) are two long slender branches of the abdominal aorta which issue below the origin of the renal arteries. Each vessel passes downwards and lateralwards to the abdominal inguinal ring crossing the psoas major, the ureter and the external iliac artery. The right artery passes in front of the inferior vena cava and behind the terminal part of the ileum and the right colic and ileocolic arteries. The left artery passes behind the iliac part of the descending colon, the left colic and sigmoid arteries. At the abdominal inguinal ring it meets the other constituents of the spermatic cord and passes along the inguinal canal to the scrotum where it breaks up into branches which supply the testis, epididymis and cremaster muscle. In the abdominal part of its course it gives off branches to the ureter and perinephric fat. In the fœtus the artery is very short as the testis lies near the kidney but elongates as the testes descends into the scrotum.

The **ovarian arteries** in the female correspond to the testicular arteries in the male. They are shorter than the testicular arteries and do not pass through the inguinal canal. In the abdomen proper they have the same course as the testicuiar arteries and enter the pelvis by crossing the commencement of the external iliac artery. In the pelvis each artery runs medialwards between the two layers of the broad ligament and passes to the anterior border of the ovary with a tortuous course. Here it gives off many small twigs which enter the ovary. It also sends twigs to the uterine tube, uterus and round ligament of the uterus and anastomoses with branches of the uterine artery. A few twigs pass along the round ligament through the inguinal canal and supply the skin of the labium majus and groin. In the fœtus the artery is very short as the ovary lies near the kidney but elongates as the ovary descends to its proper place in the pelvis.

The **inferior mesenteric artery** (Fig. 235) arises from the abdominal aorta an inch and a half above its bifurcation. It passes downwards and to the left, lying behind the peritoneum and in front of the left psoas major, crosses the left common iliac artery and is continued as the superior hæmorrhoidal artery into the rectum. It supplies the left half of the transverse colon, the descending colon, sigmoid colon and a portion of the rectum. The **branches** of the inferior mesenteric artery are: (1) left colic, (2) sigmoid, (3) superior hæmorrhoidal.

(1) The **left colic artery** (colica sinistra) passes transversely to the left and divides into an ascending and a descending branch. The former ascends to anastomose with the left branch of the middle colic artery. The latter anastomoses with the highest sigmoid artery. From the anastomotic arch twigs are supplied to the left part of the transverse colon and the descending colon. The two branches of the left colic artery lie behind the peritoneum and in front of the left ureter and left testicular vessels.

(2) The **sigmoid arteries** are two or three in number. They pass downwards and to the left behind the peritoneum and in front of the left psoas major and left ureter. The highest one anastomoses with the descending branch of the left colic and the lowest one with the superior hæmorrhoidal artery. They supply the lower part of the descending colon and the sigmoid colon.

(3) The **superior haemorrhoidal artery** is the direct continuation of the inferior mesenteric. It descends between the two layers of the sigmoid mesocolon and crosses the left common iliac vessels. At the third sacral vertebra (where the rectum begins) it divides into a right and a left branch which descend upon the sides of the rectum. These two branches give off innumerable twigs which pierce the muscular coat and enter the submucous coat where by anastomosing with the branches of the middle and inferior hæmorrhoidal arteries they form an arterial anastomotic network.

The **inferior phrenic arteries** (Fig. 233), two in number, arise from the abdominal aorta just below the diaphragm above the origin of the cœliac artery and run upwards and lateralwards to the under surface of the diaphragm. The left phrenic artery passes behind the œsophagus while the right artery passes behind the inferior vena cava. At the posterior border of the central tendon each artery divides into a medial and a lateral branch. The *medial branch* passes forwards and anastomoses with its fellow of the opposite side and with the musculophrenic artery. The *lateral branch* passes towards the lower ribs and anastomoses with the musculophrenic and lower intercostal arteries. Each phrenic artery gives off the *superior suprarenal artery* which supplies the suprarenal gland.

The **lumbar arteries** (Fig. 233), usually four in number on each side, arise from the back part of the aorta opposite the bodies of the upper four lumbar vertebræ. Occasionally a fifth pair arises from the middle sacral artery. They resemble and are in series with the intercostal arteries. They run lateralwards upon the bodies of the lumbar vertebræ, beneath the sympathetic trunk and disappear behind the psoas major by passing beneath the fibrous arches which give origin to this muscle. Arriving at the intervals between the transverse processes each artery is found to give off a posterior branch. The upper three lumbar arteries after giving off their posterior branches pass behind the quadratus lumborum while the lowest passes in front of it. They continue their course in the abdominal wall by running forwards between the internal oblique and the transversus abdominis and anastomose with the intercostal arteries, the deep circumflex iliac artery and the inferior epigastric artery. The *posterior branch* passes backwards and opposite the intervertebral canal and supplies the medulla spinalis; it also gives off branches to the muscles and skin of the back.

The **middle sacral artery** (Fig. 233) is regarded as the direct continuation of the abdominal aorta. It arises from the back of the aorta a little above its bifurcation. It descends into the pelvis minor in front of the sacrum along the middle line to the tip of the coccyx, where it supplies the glomus coccygeum. Opposite the fifth lumbar vertebra it is crossed by the left common iliac vein. On either side it anastomoses with twigs from the lateral sacral artery.

The **common iliac arteries** (Figs. 233, 236) are the terminal branches of the abdominal aorta. They commence a little to the left side of the fourth lumbar vertebra and pass downwards and lateralwards and divide opposite the lumbosacral articulation into the external iliac and hypogastric arteries. *Branches*—Besides the terminal branches they give off branches to the peritoneum, extraperitoneal fatty tissue, ureters, and psoas major.

The **right common iliac artery** is longer and more oblique in direction than the left. *In front* of it are the peritoneum, the coils of the small intestine and, close to its termination, the ureter. *Behind* it are the bodies of the fourth and fifth lumbar vertebræ and the intervertebral fibrocartilage between them and the sympathetic trunk; the artery is separated from the above structures by the terminations of the right and left common iliac veins and the commencement of the inferior vena cava. *Medial* to it are the left common iliac vein, above, and the right common iliac vein, below. *Lateral* to it are the inferior vena cava and right common iliac vein, above, and psoas major, below.

The **left common iliac artery** has *in front* the peritoneum, the coils of small intestine, the superior hæmorrhoidal artery and, close to its termination, the ureter. *Behind* it are the fourth and fifth lumbar vertebræ and the intervertebral fibrocartilage between them ; it is not in relation with any vein posteriorly. *Medial* to it is the left common iliac vein. *Lateral* to it is the psoas major.

The **hypogastric artery** (internal iliac artery) (Fig. 236) arises opposite the lumbosacral articulation from the bifurcation of the common iliac artery. It passes to the upper margin of the greater sciatic foramen and then divides into an anterior and a posterior division. *Anteriorly* it is covered by peritoneum and crossed by the ureter, while *posteriorly* are the hypogastric vein and the lumbosacral nerve trunk. *Lateral* to it are the external iliac vein, the psoas major muscle and the obturator nerve. In the fœtus the hypogastric artery is twice the size of the external iliac artery and ascends on the back part of the anterior abdominal wall to the umbilicus, where it approaches its fellow of the opposite side. The two hypogastric arteries pass through the umbilical opening to the placenta along the umbilical cord as the *umbilical arteries*. After birth the pelvic portion of the hypogastric artery remains patent and forms the hypogastric artery and the proximal portion (one to two inches) of the superior vesical artery. The remainder of the vessel up to the umbilicus is converted into a fibrous cord, called the *lateral umbilical ligament* (obliterated hypogastric artery).

**Branches of the hypogastric artery.**—From the anterior division three visceral branches viz., the superior vesical, the inferior vesical and the middle hæmorrhoidal, and three parietal branches, viz., the obturator, the internal pudendal and the inferior gluteal are given off. From the posterior division three parietal branches viz., the iliolumbar, the lateral sacral and the superior gluteal are given off. In the female the uterine and vaginal arteries are given off from the anterior division.

**Superior vesical artery.**—Its first portion is the proximal pervious portion of the fœtal hypogastric artery. It runs medially to the upper part of the bladder and gives off many small branches which supply the upper part of the bladder, the urachus and the lower end of the ureter. From one of these branches a small twig, the *artery to the ductus deferens*, is given off which accompanies the ductus deferens to the testis.

The **inferior vesical artery** usually arises in common with the middle hæmorrhoidal. It supplies the fundus of the bladder, the vesicula seminalis, the ductus deferens and the prostate.

The **middle haemorrhoidal artery** usually arises in common with the inferior vesical. It supplies the muscular coat of the rectum and anastomoses with the superior and inferior hæmorrhoidal arteries.

The **uterine artery** is a branch of the anterior division of the hypogastric artery. It proceeds medialwards upon the upper surface of the levator ani to the lower border of the broad ligament. It then passes medialwards between the two layers of the broad ligament, crosses in front of the ureter about ¾ inch from the side of the cervix, and then ascends in a tortuous manner along the side of the uterus giving several branches to it. It also gives twigs to the vagina, the uterine tube, the round ligament and the ovary, and anastomoses near its termination with branches of the ovarian artery.

The **vaginal artery** arises from the anterior division of the hypogastric artery. It descends on the floor of the pelvis to the side of the vagina where it breaks into branches which ramify on the anterior and posterior walls of the vagina and anastomose with the branches of the opposite side and with the vaginal branches of the uterine artery forming two longitudinal arteries in the medial line, called the *azygos arteries of the vagina*. The vaginal artery sends twigs to the base of the bladder, rectum, and bulb of the vestibule.

The **obturator artery** passes downwards and forwards along the lateral wall of the lesser pelvis to the obturator canal at the upper part of the obturator foramen. Lateral to it is the obturator fascia which intervenes between it and the obturator internus. Medial to it is the peritoneum which intervenes between it and the ureter and ductus deferens. In its whole course it is accompanied by the obturator nerve and vein, the nerve lying above the artery and the vein below it. In the pelvis it gives off some *iliac branches* to the iliac fossa which supply the bone and the iliacus ; a *vesical branch* which supplies the bladder ; and a *pubic branch* which ascends along the back part of the os pubis and anastomoses with the pubic branch of the inferior epigastric artery. Emerging from the obturator canal it divides into an anterior and a posterior branch. The *anterior branch* runs forwards and then downwards along the medial margin of the obturator foramen and anastomoses with the posterior branch. The *posterior branch* runs downwards along the lateral margin of the obturator foramen and then curves upwards to anastomose with the anterior branch ; this anastomosis completes an arterial circle upon the obturator membrane along the circumference of the obturator foramen under cover of the obturator externus. *Muscular branches* are given off from both the branches to the adductor muscles and the obturator externus. An *articular twig* is given off from the posterior branch which enters the hip joint through the acetabular notch.

The **internal pudendal artery** (internal pudic artery) (Figs. 133, 134, 236) passes downwards and lateralwards in front of the piriformis and the sacral plexus of nerves to the lower part of the greater sciatic foramen. It issues out of the pelvis between the piriformis and the coccygeus through the lower part of the greater sciatic foramen. It then winds over the ischial spine and enters the perineum through the lesser sciatic foramen. In the perineum it lies at first in the lateral wall of the ischiorectal fossa and is contained in Alcock's canal. It then runs forwards between the superior and inferior fasiæ of the urogenital diaphragm and close to the ischiopubic ramus. About half an inch below the symphysis pubis, it pierces the inferior layer of the urogenital diaphragm and divides into two branches, the deep artery of the penis and the dorsal artery of the penis. The artery may be divided into four portions.

The *first portion* is the intrapelvic portion of the artery and gives off branches which supply the neighbouring muscles and pelvic fascia.

The *second portion* of the artery lies upon the back of the ischial spine and under cover of the glutæus maximus. Here it lies between the pudendal nerve and the nerve to the obturator internus, the former lying medial to it and the latter, lateral to it. It gives off branches which supply the glutæus maximus.

The *third portion* of the artery is contained in Alcock's canal. The contents of *Alcock's canal* and their position from above downwards are (1) the dorsal nerve of the penis, (2) the internal pudendal artery with its venæ comites, (3) the perineal division of the pudendal nerve. The third portion gives off two branches viz. the inferior hæmorrhoidal and perineal arteries.

The *fourth portion* of the internal pudendal artery lies in the urogenital triangle. From Alcock's canal the artery enters the deep perineal pouch between the superior and inferior fasciæ of the urogenital diaphragm by piercing the base of the superior fascia near the ischial ramus. Here it lies more or less in the substance of the sphincter urethræ membranaceæ; proceeding forwards it pierces the inferior fascia of the diaphragm about half an inch below the symphysis pubis and divides into its two terminal branches. The fourth portion gives off the artery to the bulb of the urethra and two terminal branches, viz., the deep artery of the penis and dorsal artery of the penis.

The **inferior haemorrhoidal artery** arises from the third portion of the internal pudendal; it perforates the medial wall of Alcock's canal, and divides into two or three branches which cross transversely the ischiorectal fossa to supply the anal canal and the muscles and skin of the anal region. It also anastomoses with the superior and middle hæmorrhoidal arteries.

The **perineal artery** passes forwards and upwards from its origin within Alcock's canal, crosses either superficial or deep to the transversus perinei superficialis to gain the interval between the bulbocavernosus and ischiocavernosus and finally ends in several *posterior scrotal branches* which supply the scrotum. It also supplies the superficial perineal muscles. It gives off the *transverse perineal artery* which runs transversely along the surface of the transversus perinei superficialis to the central tendinous point of the perineum where it anastomoses with its fellow of the opposite side.

The **artery to the urethral bulb** arises from the internal pudendal between the two fascial layers of the urogenital diaphragm. It runs transversely medialwards and supplies twigs to the bulbourethral gland, the bulb of the urethra and corpus cavernosum urethræ.

The **deep artery of the penis** is the larger of the two terminal branches. Just after its origin it enters the crus penis, runs forwards and ramifies in the corpus cavernosum penis.

The **dorsal artery of the penis** runs upwards between the crus penis and symphysis pubis. It then passes between the two layers of the suspensory ligament of the penis and then along the dorsal surface of the penis where it has the dorsal nerve of the penis to its lateral side and the deep dorsal vein of the penis to its medial side. Reaching the neck of the penis it breaks into branches which supply the glans and prepuce ; some branches enter the corpus cavernosum penis and anastomose with the deep artery of the penis.

**In the female,** the internal pudendal artery is smaller than in the male but has an exactly similar course. The perineal artery supplies the labia pudendi. The artery to the bulb supplies the bulbus vestibuli. The deep artery of the clitoris supplies the corpus cavernosum clitoridis. The dorsal artery of the clitoris supplies the glans and prepuce of the clitoris.

The **inferior gluteal artery** (sciatic artery) (Figs. 236, 237) is one of the terminal branches of the anterior division of the hypogastric. In the pelvis it descends behind the internal pudendal artery and lies on the sacral plexus of nerves and the piriformis. Passing between the first and second sacral nerves and between the piriformis and coccygeus it leaves the pelvis through the lower compartment of the greater sciatic foramen and runs downwards between the greater trochanter and ischial tuberosity in company with the sciatic and posterior femoral cutaneous nerves. In the buttock it lies under cover of the glutæus maximus and superficial to the obturator internus, gemelli and quadratus femoris. Below the lower border of the glutæus maximus it is continued to the back of the thigh in company with the posterior femoral cutaneous nerve. It gives off the following branches :—(1) The *muscular branches* supply the periformis, the glutæus maximus and the neighbouring muscles. (2) The *coccygeal branches* pass medialwards, perforate the sacrotuberous ligament and supply the glutæus maximus and the skin over the coccyx. (3) The *arteria comitans nervi ischiadici*, a long slender artery, lies at first on the surface of the sciatic nerve and then pierces it to supply its substance. (4) The *anastomotic branch* descends to form the upper limb of the *crucial anastomosis* in which the medial and lateral femoral circumflex arteries and the superior perforating artery take part. (5) The *cutaneous branches* supply the skin of the buttock and upper part of the back of the thigh.

The **iliolumbar artery** passes upwards in front of the sacroiliac articulation and lumbosacral nerve trunk and behind the obturator nerve, the external iliac vessels and the psoas major muscle. Behind the muscle it divides into a lumbar branch and an iliac branch. The *lumbar branch* supplies the psoas major and quadratus lumborum muscles and anastomoses with the lowest lumbar artery. It sends a *spinal branch* which passes through the intervertebral foramen between the fifth lumbar vertebra and the sacrum and supplies the cauda equina. The *iliac branch* supplies the ilium and the iliacus and anastomoses with the deep circumflex iliac artery near the crest of the ilium.

The **lateral sacral arteries** are usually two in number, superior and inferior. Both descend in front of the piriformis and the sacral nerves lateral to the anterior sacral foramina. The *superior* reaches as far as the second anterior sacral foramen and then enters the sacral canal; it furnishes twigs to the contents of the sacral canal. The *inferior* reaches as far as the tip of the coccyx, where it anastomoses with the middle sacral artery; it gives off *spinal branches* which pass through the anterior sacral foramina, supply the contents of the sacral canal and pass out of the canal through the posterior sacral foramina to supply the muscles on the back of the sacrum.

The **superior gluteal artery** (gluteal artery) (Fig. 237) is the continuation of the posterior division of the hypogastric artery. It descends between the lumbosacral nerve trunk and the first sacral nerve and issues out of the pelvic cavity through the greater sciatic foramen above the piriformis and enters the buttock, where it divides under cover of the glutæus maximus, into a superficial and a deep branch. The *superficial branch* divides into several branches which enter the deep surface of the glutæus maximus; some of the branches become cutaneous at the back of the sacrum by piercing the muscle. The *deep branch* runs forwards between the glutæus medius and minimus and subdivides into a superior and an inferior division. The *superior division* proceeds forwards towards the anterior superior iliac spine by crossing the upper limit of the glutæus minimus. It anastomoses with the deep circumflex iliac artery and with the ascending branch of the lateral femoral circumflex artery. The *inferior division* crosses the surface of the glutæus minimus obliquely to the greater trochanter; it accompanies the inferior branch of the superior gluteal nerve and supplies the glutæus medius and minimus; some twigs pierce the latter muscle to supply the hip joint. Within the pelvis the superior gluteal artery gives branches to the piriformis and obturator intermus and a nutrient branch to the hip bone.

The **external iliac artery** (Figs. 233, 236) begins opposite the lumbosacral articulation at the bifurcation of the common iliac artery. It extends to a point behind the inguinal ligament midway between the symphysis pubis and the anterior superior iliac spine, where it takes the name of the femoral artery. In the adult it is larger than the hypogastric artery.

**Relations.**—It is covered *in front* by the parietal peritoneum and by a layer of condensed subperitoneal tissue, called *Abernethy's fascia*. The right artery is crossed by the termination of the ileum and some times the vermiform process; the left artery is crossed by the sigmoid colon and coils of the small intestine.

Each artery, near its origin may be crossed by the ureter, and near its end is crossed by the external spermatic branch of the genito femoral nerve and the deep iliac circumflex vein. In the female it is crossed by the ovarian vessels at its upper part and by the round ligament of the uterus at its lower part ; in the male it is crossed, near its termination, by the testicular vessels and the ductus deferens. *Behind* it are the fascia iliaca and psoas major ; behind the upper part of the artery are the external iliac vein and obturator nerve. *Medial* to it is Abernethy's fascia which binds the artery and the external iliac vein lying on the medial side of the lower part of the artery to the fascia iliaca. *Lateral* to it are the psoas major muscle covered by the fascia iliaca and the genito femoral nerve. Several iliac lymph glands and numerous lymphatic vessels lie in front and at the sides of the artery.

**Branches.**—In addition to branches to the psoas major and neighbouring lymph glands, it gives off two large branches, the inferior epigastric and deep circumflex iliac.

The **inferior epigastric artery** (deep epigastric artery) (Fig. 224) arises from the external iliac artery about one-fourth of an inch above the inguinal ligament. At first it passes medialwards, then upwards and medialwards along the medial side of the abdominal inguinal ring behind the commencement of the spermatic cord lying between the peritoneum and the fascia transversalis. Then it pierces the fascia transversalis, passes in front of the linea semicircularis to the interior of the sheath of the rectus. Inside the sheath, the artery ascends behind the rectus abdominis, supplies branches to it and anastomoses with the superior epigastric artery and lower intercostal arteries. As the artery passes to the rectus abdominis muscle it forms the boundary of a triangular space called the recto-epigastric or *Hesselbach's triangle,* the other two sides of the triangle being formed by the lateral edge of the rectus and the inguinal ligament. As it ascends along the medial side of the abdominal inguinal ring, the round ligament of the uterus in the female or the ductus deferens in the male winds round the lateral and posterior aspects of the artery. The *branches* given off from the inferior epigastric artery are :—(1) The *external spermatic artery* (cremasteric artery) accompanies the spermatic cord in the male and the round ligament of the uterus in the female and supplies the cremaster muscle. (2) The *pubic artery* passes medialwards to the back part of the pubis and anastomoses with the pubic branch of the obturator artery. (3) The *muscular branches* supply the rectus abdominis by entering its deep surface. (4) The *cutaneous branches* pierce the rectus abdominis and the anterior wall of its sheath, supply the skin and anastomose with branches of the superficial epigastric artery.

The **deep circumflex iliac artery** arises from the external iliac artery opposite the origin of the inferior epigastric artery. It passes upwards and lateralwards behind the inguinal ligament

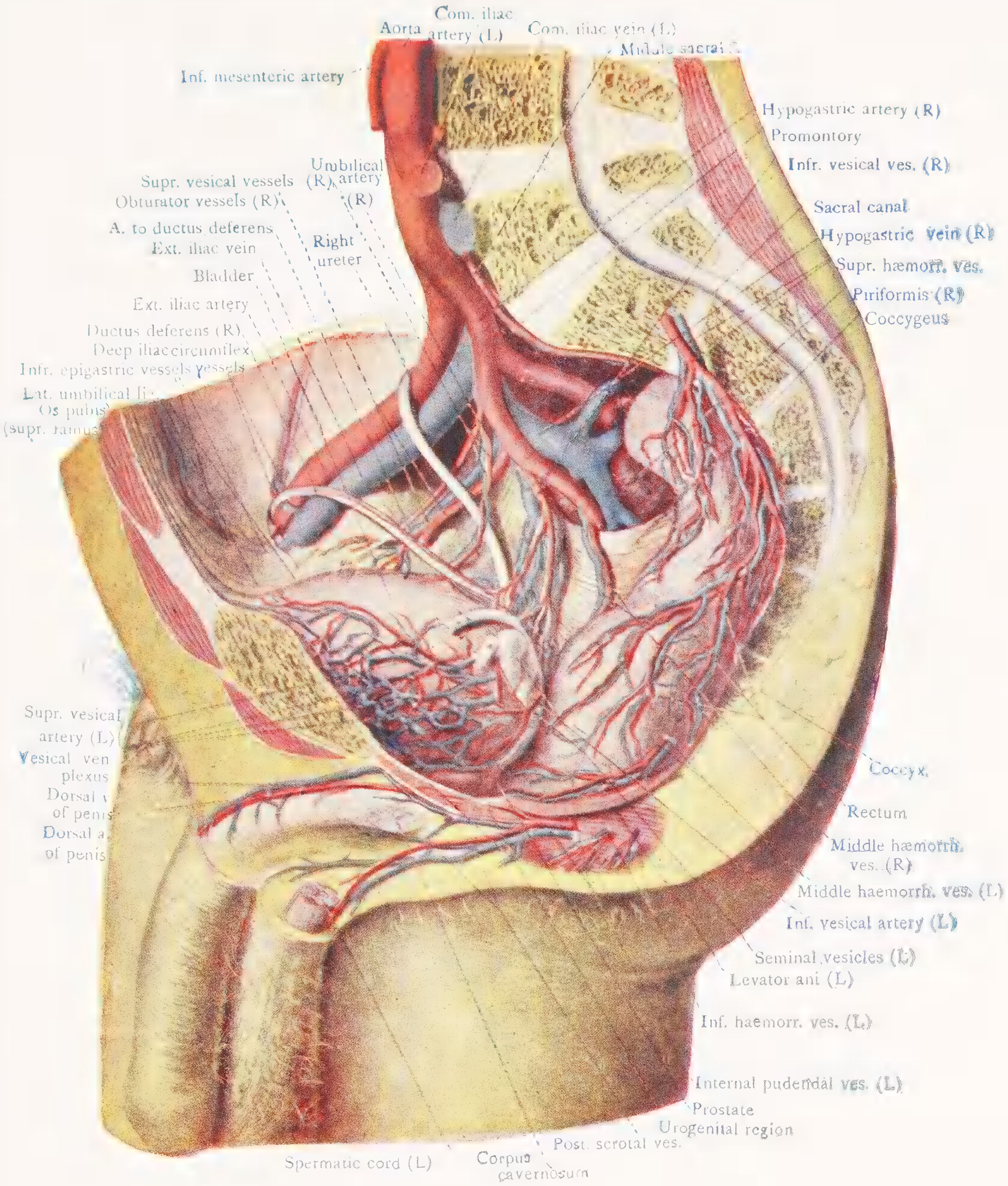

Fig. 236 —The arteries of the pelvis.

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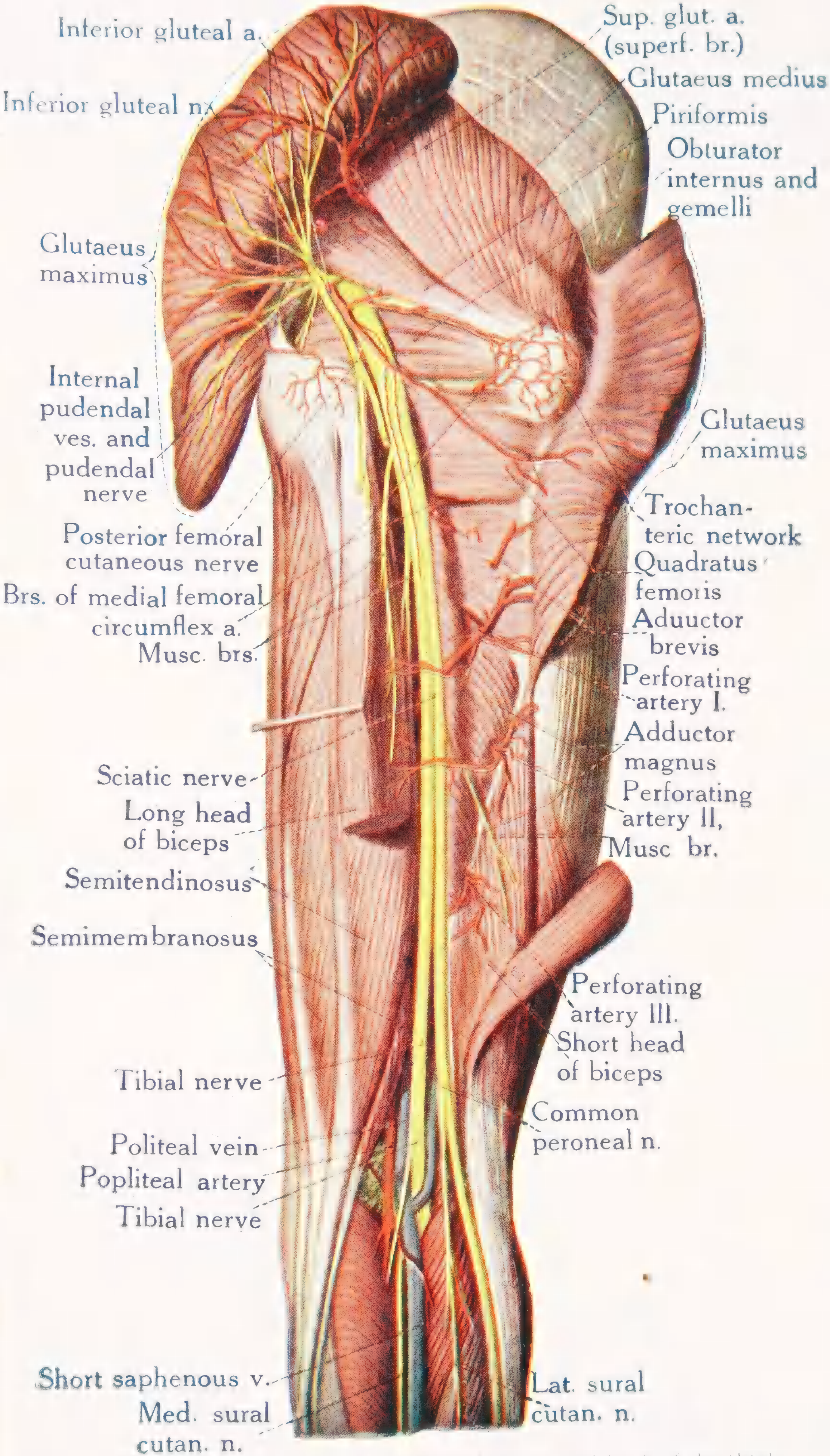

Fig. 237.—The arteries of the gluteal region and back of the thigh.

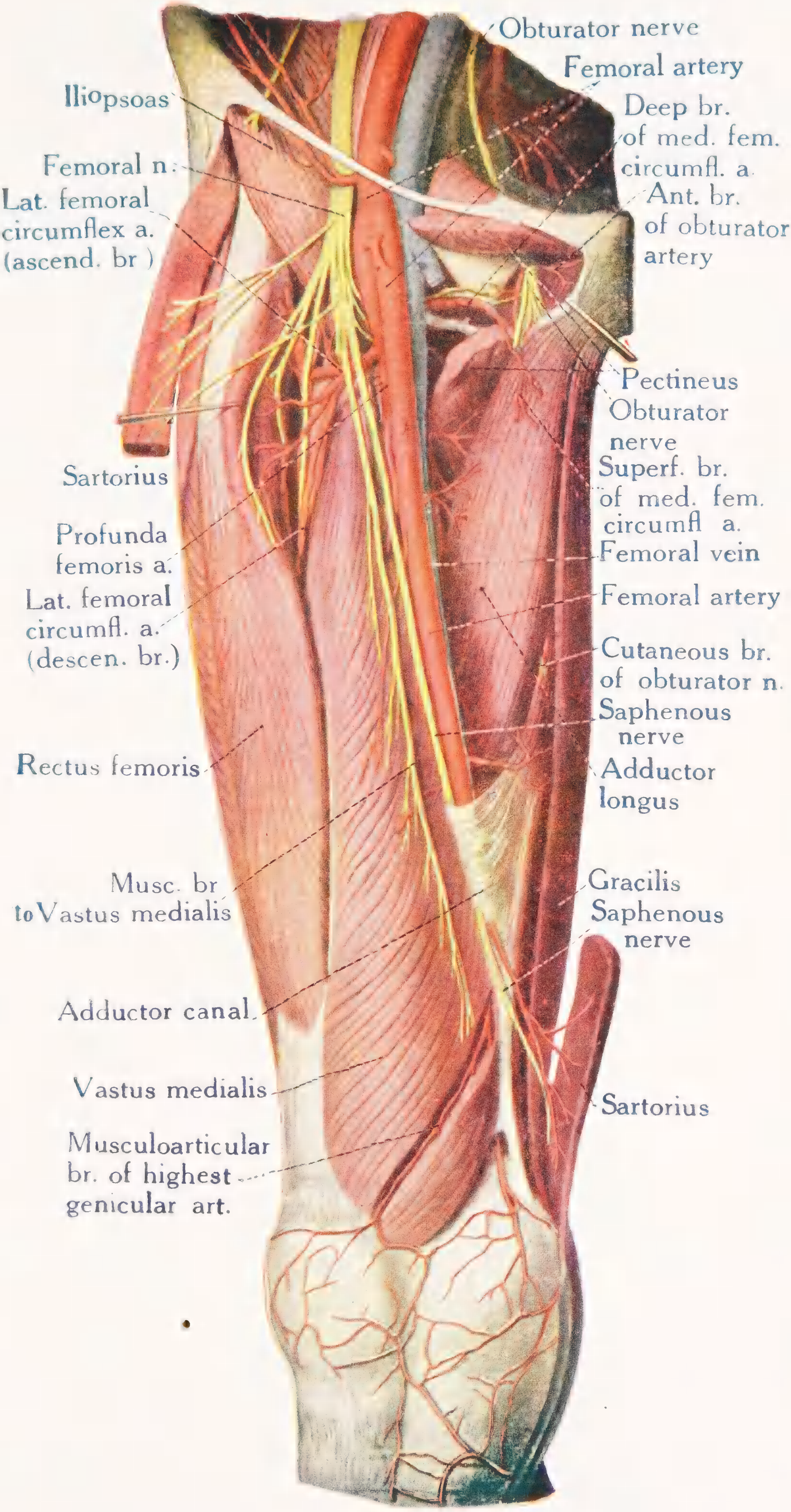
Obturator nerve
Femoral artery
Iliopsoas
Deep br. of med. fem. circumfl. a.
Femoral n.
Lat. femoral circumflex a. (ascend. br.)
Ant. br. of obturator artery
Pectineus
Obturator nerve
Sartorius
Superf. br. of med. fem. circumfl. a.
Profunda femoris a.
Femoral vein
Lat. femoral circumfl. a. (descen. br.)
Femoral artery
Cutaneous br. of obturator n.
Saphenous nerve
Rectus femoris
Adductor longus
Musc. br to Vastus medialis
Gracilis
Saphenous nerve
Adductor canal
Vastus medialis
Sartorius
Musculoarticular br. of highest genicular art.

Fig. 238.—The femoral artery and its branches.

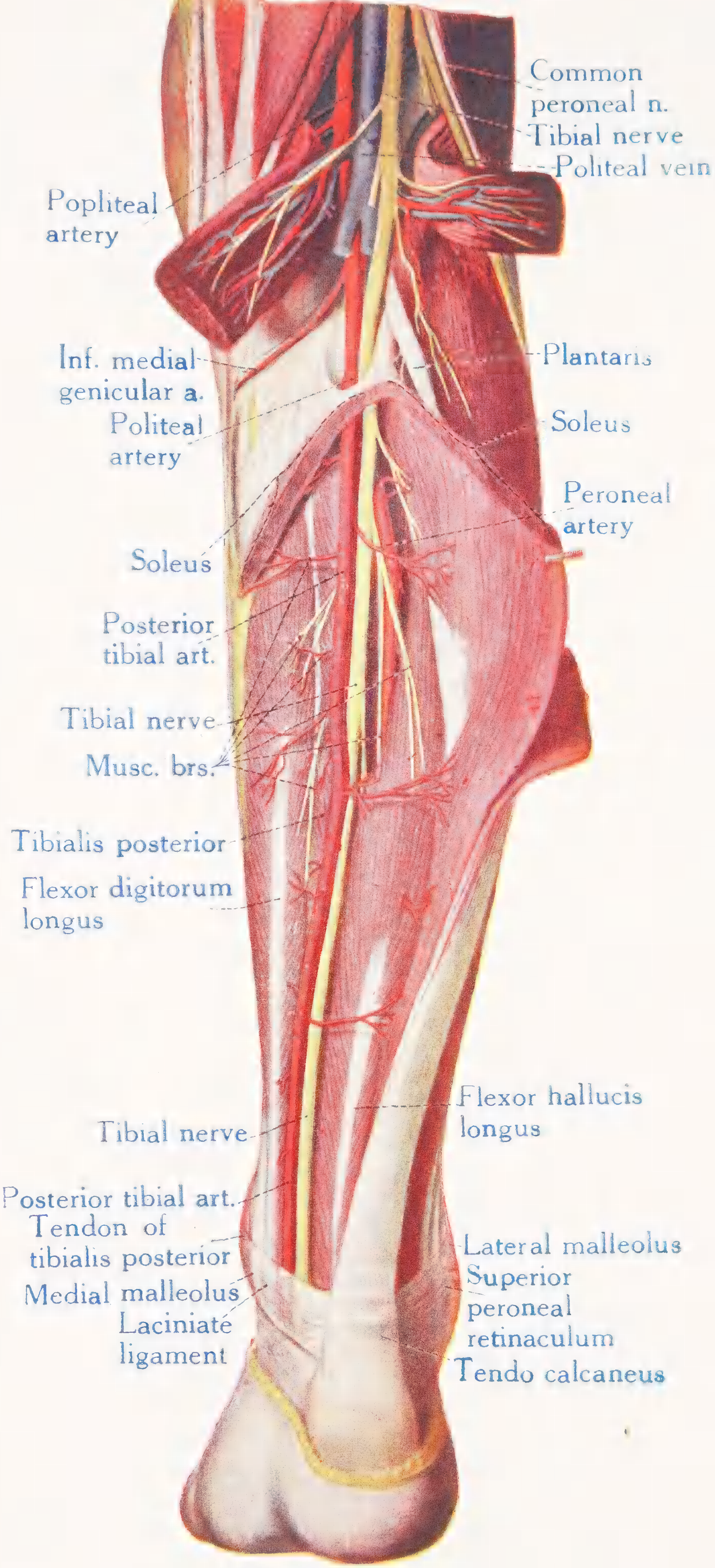

Fig. 240.—The popliteal, posterior tibial and peroneal arteries.

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between the peritoneum and the fascia transversalis. At the anterior superior iliac spine it pierces the fascia transversalis and passes backwards between it and the transversus abdominis along the iliac crest to its middle. It then pierces the transversus abdominis and is continued between the transversus and the internal oblique to end by anastomosing with the iliolumbar artery. Near the anterior superior iliac spine it gives off a large branch, the *ascending branch,* which pierces the transversus abdominis and then ascends between the transversus and the internal oblique and anastomoses with the lumbar and inferior epigastric arteries.

## ARTERIES OF THE INFERIOR EXTREMITY

The main arterial trunk of the lower limb is the continuation of the external iliac artery. It exists as a single trunk up to the lower border of the popliteus where it ends by dividing into the anterior and posterior tibial arteries. In the proximal two thirds of the thigh it receives the name of the femoral artery while the remaining portion up to the point of its bifurcation is called the popliteal artery.

### The Femoral Artery

The **femoral artery** (Fig. 238) is the continuation into the thigh of the external iliac artery. It begins at the lower border of the inguinal ligament at a point midway between the anterior superior iliac spine and the symphysis pubis and passes through the proximal two thirds of the front and medial side of the thigh and terminates at the opening in the adductor magnus where it becomes the popliteal artery. As the artery enters the thigh it is enclosed for a distance of one and a quarter inches in a loose funnel-shaped sheath called the *femoral sheath.* The upper part of the artery is contained in the femoral triangle ; the lower part occupies the adductor canal. About two inches below the inguinal ligament the femoral artery gives off a large branch called the profunda femoris. The portion of the artery proximal to the origin of the profunda femoris (or deep femoral) is sometimes named the *common femoral ;* the part below its origin, the *superficial femoral* i.e. the common femoral divides into the superficial femoral and deep femoral.

The **femoral sheath** (crural sheath) (Fig. 239) is a large, loose funnel shaped sheath containing the femoral vessels and is about an inch and a quarter in length. Its upper wide end is directed towards the abdomen. Its lower narrow end fuses with the coats of the femoral vessels behind the lower end of the fossa ovalis. The *anterior wall* of the sheath is formed by a prolongation of the fascia transversalis from the anterior abdominal wall. The *posterior wall* of the sheath is formed by a prolongation of the fascia iliaca from the posterior abdominal wall and is blended with the pectineal portion of the fascia lata. The *lateral wall* is straight and is pierced by the lumboinguinal nerve. The *medial wall* is oblique and is pierced by the great saphenous vein and lymphatic vessels. The sheath is subdivided into three compartments by two anteroposterior septa stretching between its anterior and posterior walls. The lateral compartment contains the femoral artery and the lumboinguinal nerve ; the intermediate is occupied by the femoral vein ; and the medial, called the *femoral canal*, contains a lymph gland, some lymphatic vessels and areolar tissue.

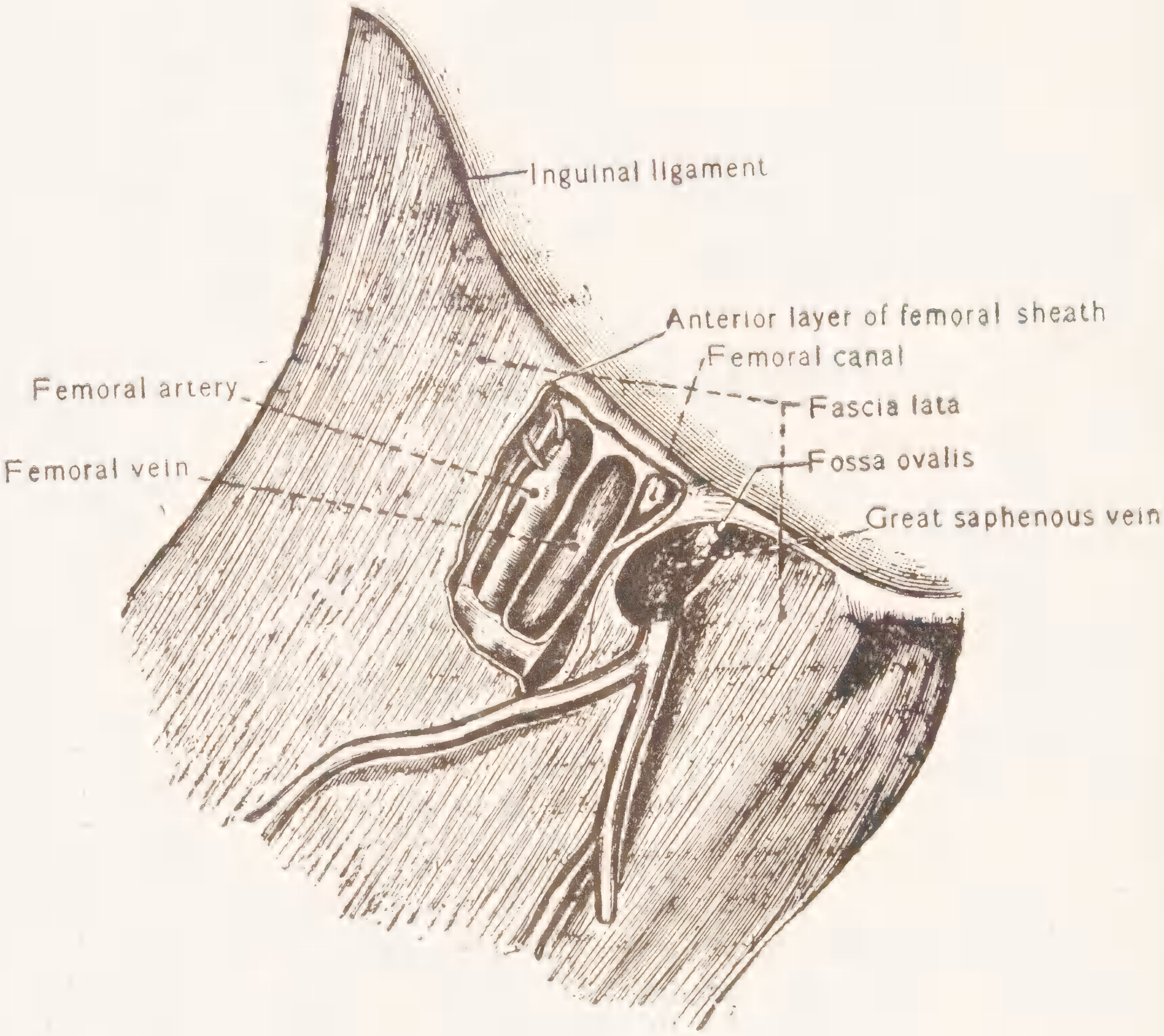

Fig. 239.—Dissection to show the femoral sheath and its three compartments.

The **femoral canal** (crural canal) (Fig. 239) is the most medial compartment of the femoral sheath and is so named on account of its special relation to femoral hernia. It is about half an inch in length and extends from the inguinal ligament to the upper end of the fossa ovalis. Its base is directed upwards and is called the *femoral ring* (crural ring). This ring is oval in shape ; its transverse diameter measures about half an inch ; it is bounded in front by the inguinal ligament, behind by the fascia covering the pectineus, medially by the concave base of the lacunar ligament, and laterally by the femoral vein. Above the anterior margin of the ring is seen the spermatic cord or the round ligament of the uterus ; near its upper limit is the inferior epigastric artery which separates the femoral ring from the abdominal inguinal ring. The ring is closed normally by condensed extraperitoneal connective tissue called the *septum femorale*. The upper surface of this septum is lined by peritoneum and presents a depression, called the *femoral fossa*, when viewed from the abdominal cavity.

**Relations of the femoral artery.**—In the *femoral triangle* the femoral artery extends from the lower border of the inguinal ligament to the apex of the femoral triangle and is quite superficial. It is covered *in front* by the skin, superficial fascia, superficial subinguinal lymph glands, the superficial circumflex iliac vein, fascia lata ; and the anterior wall of the femoral sheath at the upper part. It is crossed near the apex of the triangle by the medial femoral cutaneous nerve. The lumboinguinal nerve lies at first in front of the artery within the femoral sheath and then lateral to the artery. *Behind* it are the posterior wall of the femoral sheath, the pectineal fascia, the psoas major, the pectineus with its nerve, the adductor longus, and the profunda femoral vessels. It is separated from the adductor longus by the femoral vein ; from the pectineus by the profunda vessels and the femoral vein ; and from the capsule of the hip joint by the psoas major. *Lateral* to it is the femoral nerve. *Medially* is the femoral vein which passes behind the artery near the apex of the triangle.

In the *adductor canal*, the femoral artery is deeply situated. Besides the skin and fasciæ it has *in front* the sartorius, subsartorial plexus, the aponeurotic covering of the adductor canal, and the saphenous nerve at about its middle. *Behind* it are the adductores longus and magnus and the femoral vein at the upper part. *Lateral* to it are the vastus medialis, the saphenous nerve at the upper part, and the femoral vein at the lower part. *Medial* to it is the saphenous nerve at the lower part.

The femoral artery bears the following *relation to the femur* :—At first it rests upon the brim of the pelvis and the medial side of the head of the femur from which it is separated by the capsule of the hip joint and the psoas major. Lower down it lies at some distance from the bone because it rests upon muscles. Towards its termination, (in the adductor canal) it lies to the medial side of the femur, because the shaft of the femur is strongly inclined towards the middle line of the body.

The **branches** of the femoral artery are : (1) superficial circumflex iliac, (2) superficial epigastric, (3) superficial external pudendal, (4) deep external pudendal, (5) profunda femoris, (6) highest genicular, and (7) muscular.

The **superficial circumflex iliac artery** springs from the femoral immediately below the inguinal ligament. Piercing the femoral sheath and the fascia lata a little to the lateral side of the fossa ovalis, it runs more or less parallel to the inguinal ligament as far as the anterior superior iliac spine where it sends twigs to anastomose with the deep circumflex iliac artery. It supplies the iliacus, sartorius, lateral set of subinguinal glands and the skin of the groin.

The **superficial epigastric artery** arises close to the preceding. Piercing the femoral sheath and fascia cribrosa, it runs upwards and crosses the inguinal ligament. It then passes between the two layers of the superficial fascia of the anterior abdominal wall and reaches as high as the umbilicus. It anastomoses with its fellow of the opposite side and the inferior epigastric artery. It supplies the subinguinal lymph glands and the skin.

The **superficial external pudendal artery** arises close to the preceding. Piercing the femoral sheath and fascia cribrosa, it runs medialwards towards the pubic tubercle, crosses in front of the spermatic cord or round ligament of the uterus and is distributed to the scrotum and penis in the male and the labium majus in the female. It anastomoses with the deep external pudendal and internal pudendal arteries.

The **deep external pudendal artery** arises at a lower level and lies on a deeper plane than the three superficial branches of the femoral artery. It runs medialwards over the pectineus and adductor longus to the medial side of the thigh where it pierces the fascia lata and supplies the scrotum in the male and labium majus in the female. It anastomoses with the superficial external pudendal and perineal arteries.

The **arteria profunda femoris** (Figs. 237, 238), the largest branch, arises from the lateral side of the femoral artery about one and a half inches below the inguinal ligament. It runs downwards and lies for a little distance lateral to the femoral artery. It next proceeds medialwards so that it lies behind the femoral artery and vein and upon the pectineus. It then runs downwards under cover of the adductor longus to the lower third of the thigh, where, much reduced in size, it perforates the adductor magnus and passes to the back of the thigh. Its terminal part is known as the *fourth perforating artery*. In its course the profunda artery lies successively upon the iliacus, pectineus, adductor brevis and adductor magnus.

The **branches** of the profunda femoris are (1) muscular, (2) lateral femoral circumflex, (3) medial femoral cricumflex, (4) perforating.

The **muscular branches** supply the adductores ; others pierce the adductor magnus and supply the hamstrings.

The **lateral femoral circumflex artery** arises from the lateral aspect of the parent trunk and passes laterally between the divisions of the femoral nerve and under cover of the sartorius and rectus femoris. It terminates by dividing into ascending, transverse, and descending branches. The *ascending branch* runs upwards under cover of the tensor fasciæ latæ towards the anterior superior iliac spine where it anastomoses with the superior gluteal artery. The *transverse branch* is small ; it proceeds transversely lateralwards between the vastus lateralis and vastus intermedius, and pierces the former muscle ; winding round the outer side of the femur it reaches the back of the thigh where it anastomoses with the medial femoral circumflex, inferior gluteal and first perforating arteries and thus helps to form the crucial anastomosis. The *descending branch* passes downwards on the vastus lateralis accompanied by the nerve to that muscle. It supplies the muscle and anastomoses with the superior lateral genicular branch of the popliteal artery on the lateral side of the knee.

The **medial femoral circumflex artery** arises from the postero-medial aspect of the femoral, at the same level as the lateral femoral circumflex ; it passes directly backwards to the medial side of the femur, lying at first between the pectineus and psoas major and then between the adductor brevis and obturator externus and terminates at the upper margin of the adductor magnus by dividing into a superficial and a deep branch. It gives off (*a*) *muscular branches* to the neighbouring muscles ; (*b*) an *acetabular branch* which enters the acetabular notch beneath the transverse acetabular ligament to supply the interior of the hip joint ; (*c*) the *superficial branch* which passes between the quadratus femoris and the upper border of the adductor magnus, anastomoses with the transverse branch of the lateral femoral circumflex artery and thus contributes to the formation of the crucial anastomosis ; (*d*) the *deep branch* which passes obliquely upwards between the quadratus femoris and the obturator externus towards the trochanteric fossa and anastomoses with the superior and inferior gluteal arteries.

The **perforating arteries**, including the terminal part of the profunda artery, are four in number, and are so called because they perforate in an almost regular manner the adductor muscles. All of them pass backwards close to the linea aspera of the femur and are provided with tendinous arches which break the continuity of muscular attachments and afford protection to them during the contraction of the muscle. The *first perforating artery* pierces the insertions of both the adductors brevis and magnus ; it sends an ascending branch which takes part in the crucial anastomosis by anastomosing with the inferior gluteal, medial and lateral femoral circumflex arteries ; it sends a descending branch which anastomoses with the second perforating artery. The *second perforating artery* pierces both adductors brevis and magnus and anastomoses with the first perforating artery above and with the third perforating artery below ; it gives off the *nutrient artery* of the femur. The *third perforating artery* pierces the adductor magnus and anastomoses with the second perforating above and the terminal part of the profunda femoris below. The *fourth perforating artery* pierces the adductor magnus a little above the aperture in the muscle for the femoral artery. It anastomoses with the third perforating artery above and with the muscular branches of the popliteal artery below. All the four perforating arteries supply branches to the hamstrings ; the first artery pierces the insertion of the glutæus maximus ; the other three pierce the short head of the biceps femoris and the lateral intermuscular septum. They form an anastomotic chain on the back of the thigh which is continued into the gluteal region above and the popliteal fossa below and thus blood can flow from the gluteal artery to the popliteal artery.

The **highest genicular artery** (anastomotica magna) arises just before the femoral artery leaves the adductor canal. It soon divides into two branches, a saphenous and a musculoarticular branch. The *saphenous branch* pierces the aponeurotic roof of the adductor canal, and, accompanied by the saphenous nerve it descends to the medial side of the knee where it anastomoses with the medial inferior genicular artery. The *musculo-articular branch* descends along the medial side of the thigh through the substance of the vastus medialis and anastomoses with the medial superior genicular artery ; from it a branch passes laterally above the patellar surface of the femur and anastomoses with the lateral superior genicular artery forming an anastomotic arch.

The **muscular branches** of the femoral artery supply the sartorius, vastus medialis, pectineus and adductor muscles.

The **popliteal artery** (Fig. 240) is the continuation of the femoral artery. It begins at the aperture in the adductor magnus and ends below at the lower border of the popliteus and on a level with the lower border of the tuberosity of the tibia, by dividing into anterior and posterior tibial arteries. **Relations.**—*Anterior* or *deep.*—The upper part of the artery has an oblique course and lies upon the popliteal surface of the femur ; the lower part of the artery has a straight vertical course and lies upon the oblique popliteal ligament of the knee joint and the fascia covering the popliteus. *Posterior* or *superficial.*—It is covered by the semimembranosus above and by the gastrocnemius and plantaris below. It is crossed about its middle by the popliteal vein and tibial nerve, the vein intervening between the artery and nerve. The popliteal vein is firmly connected with the artery by dense fibrous tissue. The relation of the vein to the artery is the same as that of the tibial nerve, viz., in the upper part of the fossa it lies lateral to the artery ; opposite the middle part it crosses the artery superficially ; and in the lower part it lies medial to the artery. *Lateral.*—Above, biceps femoris, tibial nerve, popliteal vein and lateral condyle of the femur ; below, lateral head of the gastrocnemius and plantaris. *Medial.*—Above, semimembranosus and medial condyle of the femur ; below, the medial head of the gastrocnemius, tibial nerve and popliteal vein. Lymph glands lie along the sides of the artery and usually one gland lies deep to it.

The **branches** of the popliteal artery are muscular, cutaneous, and genicular. (1) The *muscular branches* consist of a superior and an inferior group. The *superior muscular branches* are given off at the upper part of the fossa and supply the hamstring muscles. The *inferior muscular* or *sural branches* supply the gastrocnemius, the soleus, and the plantaris. (2) The *cutaneous branches* arise from the popliteal artery or from its sural branches.

They perforate the deep fascia to supply the skin over the upper part of the back of the leg. (3) The *genicular branches* are five in number, two superior, two inferior, and one middle. The *medial superior genicular* artery (superior internal articular artery) arises from the popliteal artery above the level of the medial condyle of the femur and, passing transversely medialwards, winds round the femur beneath the semimembranosus and adductor magnus just above the origin of the medial head of the gastrocnemius and enters the vastus medialis. It anastomoses with the highest genicular and lateral superior genicular artery. The *lateral superior genicular artery* (superior external articular artery) arises at the same level as the preceding branch and passes transversely lateralwards to wind round the femur beneath the biceps femoris above the origin of the lateral head of the gastrocnemius and the plantaris and enters the vastus intermedius. It anastomoses with the highest genicular, the descending branch of the lateral femoral circumflex and with the lateral inferior genicular artery. The *middle genicular artery* (azygos articular artery) arises from the popliteal artery opposite the bend of the knee joint and pierces the oblique popliteal ligament to supply the synovial stratum. The *medial inferior genicular artery* (inferior internal articular artery) passes medialwards along the upper margin of the popliteus and gains the front aspect of the limb beneath the tibial collateral ligament. It anastomoses with the lateral inferior genicular and medial superior genicular arteries. The *lateral inferior genicular artery* (inferior external articular artery) passes lateralwards beneath the tendon of the biceps femoris and the fibular collateral ligament above the head of the fibula. It anastomoses with the medial inferior genicular and lateral superior genicular arteries.

The **anterior tibial artery** (Fig. 241), one of the terminal branches of the popliteal artery, begins at the lower border of the popliteus and ends in front of the ankle midway between the two malleoli where it takes the name of dorsalis pedis artery. **Course and relations.**—At its commencement it lies at the back of the leg and then passing forwards between the two heads of the tibialis posterior, gains the front aspect of the leg by passing through an aperture in the upper part of the interosseous membrane. It then descends in front of the interosseous membrane, lying at first between the tibialis anterior medially and the extensor digitorum longus laterally. Thereafter it lies between the tibialis anterior medially and the extensor hallucis longus laterally. In the lower third of the leg it lies in front of the lower end of the tibia and is overlapped by the tendon of the extensor hallucis longus which, immediately proximal to the ankle joint, crosses it and reaches its medial side. Near the ankle it is covered by the transverse and cruciate crural ligaments. Finally the artery is continued on the dorsum of the foot as the dorsalis pedis artery. The deep peroneal nerve lies on the lateral side of the artery in the upper part of the leg; in front of the artery in the middle of the leg; and again on the lateral side in the lower part. Two venæ comites accompany the artery.

The **branches** of the anterior tibial are:—(1) The *posterior tibial recurrent artery* is not always present. It arises from the parent trunk on the back of the leg. It passes upwards under cover of the popliteus, supplies the proximal tibiofibular joint and anastomoses with the inferior genicular branches of the popliteal artery. (2) The *fibular branch* passes lateralwards behind the neck of the fibula and supplies the adjacent muscles. Sometimes this branch arises from the posterior tibial artery. (3) The *anterior tibial recurrent artery* arises from the parent trunk as soon as it reaches the front of the leg. It ascends through the fibres of the tibialis anterior and anastomoses with the inferior genicular branches of the popliteal artery. (4) The *muscular branches* are given off from either side of the artery and supply the muscles in front of the leg. (5) The *anterior medial malleolar artery* (internal malleolar artery) arises from the parent trunk in front of the lower end of the tibia. It passes medialwards behind the tendon of the tibialis anterior and anastomoses on the medial malleolus with the posterior medial malleolar branch of the posterior tibial artery and the medial tarsal branches of the dorsalis pedis forming the *medial malleolar network*. (6) The *anterior lateral malleolar artery* (external malleolar artery) arises a little below the preceding artery. It passes lateralwards behind the tendons of the extensor digitorum longus and the peronæus tertius to the lateral aspect of the lateral malleolus and anastomoses with the perforating and the lateral calcaneal branches of the peroneal artery and the lateral tarsal artery forming the *lateral malleolar network*.

The **dorsalis pedis artery** (Fig. 241) is the continuation of the anterior tibial artery on the dorsum of the foot. It commences at a point midway between the two malleoli in front of the ankle joint and passes forwards to the proximal part of the first intermetatarsal space where it divides into two terminal branches, viz., the first dorsal metatarsal and deep plantar arteries. **Relations.**—The artery is very superficial, as, with the exception of the innermost tendon of the extensor digitorum brevis which crosses the artery near its termination, it is covered only by skin and fascia, including the cruciate crural ligament. On its medial side is the tendon of the extensor hallucis longus; on its lateral side are the most medial tendon of the extensor digitorum longus and the terminal part of the deep peroneal nerve. It rests upon the articular capsule of the ankle joint, the talus, navicular, and second cuneiform bones. Two venæ comites accompany it.

The **branches** of the dorsalis pedis artery are:—(1) The *lateral tarsal artery* arises as the parent trunk lies over the navicular bone. It passes lateralwards under cover of the extensor digitorum brevis and anastomoses with the lateral plantar artery laterally, with the arcuate artery in front, and with the anterior lateral malleolar artery and terminal part of the peroneal artery above. (2) The *medial tarsal arteries* are two or three twigs which pass towards the medial border of the foot and anastomose with the anterior medial malleolar artery, and help in the formation of the medial malleolar network. (3) The *arcuate artery* (metatarsal artery) passes lateralwards across the bases of the metatarsal bones under cover of the tendons of the extensor digitorum brevis and anastomoses with the lateral plantar and lateral tarsal arteries. At the proximal parts of the second, third, and fourth interosseous spaces it gives off the *second, third,* and *fourth dorsal metatarsal arteries* respectively. These pass along the corresponding interosseous spaces and opposite the clefts between the toes each bifurcates into two *dorsal digital arteries* to supply the contiguous sides of the adjoining toes. The fourth dorsal interosseous artery gives off a branch which supplies the lateral side of the little toe. Soon after their origin the dorsal metatarsal arteries are joined by the posterior perforating branches of the plantar arch and near the heads of the metatarsal bones, they are joined by the anterior perforating branches of the plantar metatarsal arteries. (4) The *first dorsal metatarsal artery* (arteria dorsalis hallucis) passes forwards on the first interosseous space, and like the other dorsal metatarsal arteries, bifurcates to supply the contiguous sides of the great and second toes. It gives off a branch which supplies the medial side of the great toe. (5) The *deep plantar artery* is the continuation of the dorsalis pedis artery. It dips between the two heads of origin of the first dorsal interosseous muscle at the proximal part of the first intermetatarsal space and completes the plantar arch by joining the lateral plantar artery at the sole of the foot.

The **posterior tibial artery** (Fig. 240) begins at the bifurcation of the popliteal at the lower border of the popliteus. It passes downwards and medialwards and terminates under cover of the laciniate ligament midway between the tip of the medial malleolus and the most prominent part of the heel, by dividing into the medial and lateral plantar arteries. **Relations.**—In the upper two-thirds of its course it is covered by the gastrocnemius, soleus, plantaris, and the deep transverse fascia of the leg. In the lower third it lies superficially, being covered by the superficial and deep fasciæ, and runs along the medial side of the tendo calcaneus. From above downwards the vessel lies on the tibialis posterior, the flexor digitorum longus, the lower end of the tibia, and the back part of the ankle joint. The tibial nerve lies medial to the artery in the upper third of its course, then crosses the artery superficially and lies on its lateral side in the lower two-thirds. Under cover of the laciniate ligament the artery and its venæ comites lie in an osseofibrous canal with the tibial nerve on its lateral side; here the tendon of the flexor hallucis longus lies lateral to it and the tendons of the tibialis posterior and flexor digitorum longus lie medial to it. The posterior tibial artery is accompanied by two venæ comites, one on each side.

The **branches** of the posterior tibial artery are:—(1) peroneal, (2) nutrient, (3) muscular, (4) communicating, (5) posterior medial malleolar, (6) medial calcaneal, (7) medial plantar, and (8) lateral plantar.

(1) The **peroneal artery** arises about an inch below the origin of the parent trunk. It passes downwards and lateralwards towards the fibula lying on the surface of the tibialis posterior. It then descends close to the posteromedial border of the fibula and runs either through a fibrous canal between the tibialis posterior and the flexor hallucis longus or through the fibres of the latter muscle. About two inches above the ankle joint it emerges from the flexor hallucis longus, passes behind the inferior tibiofibular joint to the lateral surface of the calcaneus where it divides into lateral calcaneal branches. The *branches* given off from the peroneal artery are:—(*a*) *muscular branches* which supply the adjacent muscles; (*b*) *nutrient artery of the fibula* which enters the nutrient foramen on the posterior surface of the bone; (*c*) *perforating branch* (anterior peroneal artery) which pierces the lower part of the interosseous membrane about two inches above the lower end of the lateral malleolus and gains the front aspect of the leg; it passes laterally and descends behind the peroneus tertius to the lateral side of the tarsus anastomosing with the anterior lateral malleolar and lateral tarsal arteries; (*d*) *communicating branch* which arises about two inches above the ankle joint and passes transversely medialwards to anastomose with the communicating branch of the posterior tibial artery; (*e*) *lateral calcaneal branches* which are the terminal branches of the peroneal artery and ramify on the lateral and posterior surfaces of the calcaneus anastomosing with the lateral malleolar arteries.

(2) The *nutrient artery of the tibia* arises close to the origin of the parent trunk and enters the nutrient foramen of the tibia just below the popliteal line. (3) The *muscular branches* supply the soleus and the deep group of muscles. (4) The *communicating branch* arises about two inches above the ankle joint and passes transversely lateralwards under cover of the flexor hallucis longus to anastomose with the communicating branch of the peroneal artery. (5) The *posterior medial malleolar artery* passes medialwards under cover of the flexor digitorum longus and the tibialis posterior, winds round the medial malleolus to anastomose in front of it with the anterior medial malleolar branch of the anterior tibial artery forming the *medial malleolar network*. (6) The *medial calcaneal branches* arise near the termination of the posterior tibial artery. They pierce the laciniate ligament and supply the skin around the heel and the sole of the foot.

(7) The **medial plantar artery** (internal plantar artery) (Fig. 242) is the smaller of the two terminal branches of the posterior tibial artery. At first it lies covered by the laciniate ligament and then by the abductor hallucis. It next passes forwards lying between the abductor hallucis and the flexor digitorum brevis and

terminates by anastomosing with the plantar digital artery at the medial side of the great toe. *Branches.*—(1) *Muscular branches* supply the neighbouring muscles. (2) *Cutaneous branches* perforate the plantar aponeurosis to supply the skin. (3) *Three superficial digital branches* accompany the first three common plantar digital branches of the medial plantar nerve to the clefts between the toes and end by joining the first, second, and third plantar metatarsal arteries respectively.

(8) The **lateral plantar artery** (external plantar artery) (Fig. 242) is the larger of the two terminal branches of the posterior tibial artery and lies at its origin under cover of the laciniate ligament and the abductor hallucis. It runs obliquely lateralwards lying between the flexor digitorum brevis and the quadratus plantæ. It then turns forwards between the flexor digitorum brevis and the abductor digiti quinti to the base of the fifth metatarsal bone. This portion of the artery is superficial and is accompanied by the lateral plantar nerve. The artery then takes a deep course and is accompanied by the deep branch of the lateral plantar nerve; close to the base of the fifth metatarsal bone it turns abruptly medialwards, lies on a deeper plane by passing across the bases of the metatarsal bones and the interosseous muscles and at the lateral side of the base of the first metatarsal bone joins the deep plantar branch of the dorsalis pedis artery, thus completing the plantar arch. The *branches* of the lateral plantar artery are:—(1) *medial calcanean branches* which supply the medial side of the heel; (2) *muscular branches* which supply the neighbouring muscles; (3) *cutaneous branches* which supply the skin of the lateral side of the foot.

The **plantar arch** (Fig. 242) is the portion of the lateral plantar artery which extends from the base of the fifth metatarsal bone to the proximal part of the first intermetatarsal space where it is joined by the deep plantar branch of the dorsalis pedis artery. The *branches* given off from the plantar arch are:—(1) *Articular twigs* are given to the tarsal joints. (2) The *posterior perforating branches.* These are three in number and pass dorsally through the back part of the second, third, and fourth intermetatarsal spaces to join the corresponding dorsal metatarsal arteries. (2) The *plantar metatarsal arteries* are four in number and pass forwards, one in each intermetatarsal space; each divides opposite the cleft between two adjacent toes into two plantar digital branches which supply the contiguous sides of these toes. Before division each plantar metatarsal artery sends dorsally an *anterior perforating branch* which joins the corresponding dorsal metatarsal artery between the heads of the metatarsal bones. The *first plantar metatarsal artery,* (arteria magna hallucis), arises from the junction of the lateral plantar with the deep plantar artery and runs forwards to the cleft between the great toe and second toe where it divides into two branches which supply the contiguous sides of the first and second toes; before division it sends a digital branch to the medial side of the great toe which is joined by the terminal part of the medial plantar artery. The digital branch for the lateral side of the little toe arises from the lateral end of the plantar arch.

**Crucial anastomosis** (Fig. 237).—This arterial anastomosis is formed at the upper and back part of the thigh by the anastomotic branch of the inferior gluteal artery superiorly ; the ascending branch of the first perforating artery inferiorly ; the transverse branch of the lateral femoral circumflex artery laterally ; and the terminal superficial branch of the medial femoral circumflex artery medially.

**Arterial anastomosis around the knee joint** (Fig. 238).—The arteries which engage themselves in the anastomosis around the knee joint form a superficial network and a deep network. The *superficial network* takes the form of two arches : the proximal arch is situated in front of the tendon of the quadriceps femoris and is formed by the union of the medial and lateral superior genicular arteries, the network being completed at the sides by the union of the descending branch of the lateral femoral circumflex artery and the musculoarticular branch of the highest genicular artery ; the distal arch is situated in front of the ligamentum patellæ and is formed by the union of the medial and lateral inferior genicular arteries. The *deep network* takes also the form of two arches : the proximal arch is situated deep to the tendon of the quadriceps femoris and is formed by the union of the medial and lateral superior genicular arteries ; the distal arch is situated deep to the ligamentum patellæ and is formed by the union of the medial and lateral inferior genicular arteries, and this anastomosis is supplemented at the lateral side by the union of the fibular and anterior tibial recurrent arteries.

The **anastomosis around the ankle joint** (Fig. 241) takes the form of two networks called the medial and lateral malleolar networks. The *medial malleolar network* lies below the medial malleolus and is formed by the anterior medial malleolar branch of the anterior tibial artery, the posterior medial malleolar and medial calcaneal branches of the posterior tibial artery, and the medial tarsal branches of the dorsalis pedis artery. The *lateral malleolar network* lies below the lateral malleolus and is formed by the anterior lateral malleolar branch of the anterior tibial artery, the perforating and lateral calcaneal branches of the peroneal artery, and the lateral tarsal branch of the dorsalis pedis artery.

## THE VEINS

The venous blood is collected from the capillaries (p. 361) by venules. These venules form by union large veins which receive tributaries in their course and form larger veins. Ultimately three large trunks, viz., the superior vena cava, the inferior vena cava and the coronary sinus, are formed and open into the right atrium. Four other large trunks viz., the four pulmonary veins, open into the left atrium. Like the arteries the veins communicate freely with one another. Such communications are very important in certain parts of the body e.g. the emissary veins, establishing communication between venous sinuses in the interior of the craninun and the veins of the neck.

The veins consist of two groups: the **pulmonary** and the **systemic.** In addition to these two groups there is a third group which constitutes the **veins of the portal system.**

The pulmonary veins belong to the pulmonary system. The systemic veins convey the blood to the right atrium of the heart and consist of three sets: (1) The *superficial veins* ramify over the superficial fascia and ultimately end in deep veins. (2) The *deep veins* run as companions to the arteries; a large artery like the axillary or femoral has one companion vein, while a small artery like the brachial or tibial or of smaller size is accompanied by a pair of veins called *venae comites.* (3) The *venous sinuses* are seen mostly in the interior of the cranium. The veins of the portal system constitute a separate group which convey blood from the abdominal part of the alimentary canal and from the spleen and pancreas to the liver. Only one vein, the *visceral vein,* accompanies each visceral artery. The walls of the veins are supplied with arteries and nerves. These walls are composed of three coats like those of the arteries. The veins are often provided with valves for the prevention of backward flow of blood.

### The Pulmonary Veins

The **pulmonary veins** (Fig. 207) convey arterial or oxygenated blood from the lungs to the left atrium of the heart. The tributaries of the pulmonary veins arise from the capillaries in the walls of the alveoli of the lungs. The smaller veins unite to form larger vessels which again unite to form a single vein for each lobe of the lung. The vein from the middle lobe of the right lung joins with that from the upper lobe before the latter reaches the hilum. In this way four terminal pulmonary veins are formed, two for each lung. The *right pulmonary veins* pass behind the superior vena cava and the right atrium, and open separately into the upper and posterior part of the left atrium. The *left pulmonary veins* pass in front of the descending aorta and open into the upper and posterior part of the left atrium usually by separate orifices or sometimes by one common orifice. All four pulmonary veins while perforating the pericardium are covered with the serous layer of this membrane. In the root of the lung, the upper pulmonary vein, on each side, lies below and in front of the pulmonary artery; the lower pulmonary vein, on each side, occupies the lowest part of the root and a plane posterior to that of the upper vein.

## THE SYSTEMIC VEINS

The **systemic veins** are **classified** into three groups: (1) the veins of the heart; (2) the veins of the head and neck, superior extremity and thorax which terminate in the superior vena cava ; (3) the veins of the inferior extremity, abdomen and pelvis which terminate in the inferior vena cava.

### The Veins of the Heart (Figs. 206, 207)

The **veins** which return the blood from the substance of the heart are :—(1) the **coronary sinus** which is a dilated venous channel situated in the coronary sulcus on the diaphragmatic surface of the heart between the left atrium and the left ventricle. It is about 1 inch in length and opens by its right end into the right atrium of the heart between the opening of the inferior vena cava and the right atrioventricular orifice. Its orifice is guarded by a semilunar valve, the *valve of the coronary sinus* (valve of Thebesius). (2) The *great cardiac vein* begins at the apex of the heart. It ascends along the anterior longitudinal sulcus and turns to the left in the coronary sulcus. It then curves round the left margin of the heart to open into the left end of the coronary sinus. In its course it receives several small veins including the *left marginal vein* which ascends along the left margin of the heart. (3) The *inferior cardiac vein* of the left ventricle runs upwards along the diaphragmatic surface of the left ventricle and opens into the coronary sinus. (4) The *middle cardiac vein* ascends along the posterior longitudinal sulcus and opens into the coronary sinus. (5) The *anterior cardiac veins* are usually three or four in number and run along the sternocostal surface of the right ventricle. They open directly into the lower part of the atrium. (6) The *small cardiac vein* (right coronary vein) lies in the coronary sulcus between the right atrium and ventricle, curves round the right margin of the heart and opens into the right extremity of the coronary sinus. It receives the *right marginal vein* which runs along the inferior border of the heart. (7) The *oblique vein of the left atrium* (oblique vein of Marshall) begins at the ligament of the left vena cava and terminates in the left extremity of the coronary sinus by passing obliquely along the posterior aspect of the left atrium. (8) The *venae cordis minimae* or *smallest cardiac veins* (venæ Thebesii) are minute veins which commence in the muscular substance of the heart and terminate directly into the atria ; few open into the ventricles. The tributaries of the coronary sinus are the great, inferior, small, and middle cardiac veins and the oblique vein of the left atrium ; all the tributaries are provided with valves at their orifices, except the last named.

## THE VEINS OF THE HEAD AND NECK

The veins of the head and neck may be subdivided into six groups: (1) the veins of the exterior of the head and face ; (2) the emissary veins and diploic veins ; (3) the venous sinuses of the dura mater and the meningeal veins ; (4) the veins of the orbit ; (5) the veins of the brain ; (6) the veins of the neck.

**The Veins of the Exterior of the Head and Face** (Fig. 243). The veins of this group are : the occipital, posterior auricular, superficial temporal, frontal, supraorbital, angular, anterior facial, posterior facial, pterygoid plexus, and internal maxillary.

The **occipital vein** begins at the posterior part of the skull, pierces the occipital origin of the trapezius and passes into the suboccipital triangle. It terminates in the deep cervical and vertebral veins. It sometimes opens into the external jugular vein and occasionally into the internal jugular vein. It receives (1) the mastoid emissary vein which connects it with transverse sinus and (2) the parietal emissary vein which connects it with the superior sagittal sinus. The occipital diploic vein joins it.

The **posterior auricular vein** begins on the side of the head, descends with the artery of the same name behind the ear and joins the posterior division of the posterior facial vein to form the external jugular vein.

The **superficial temporal vein** drains the blood from the parietal region of the scalp. It is formed by the union of the frontal and parietal branches which accompany the corresponding branches of the superficial temporal artery. It passes downwards, and above the zygomatic arch it is joined by the *middle temporal vein ;* it then crosses the zygomatic arch and ultimately, in the substance of the parotid gland, is joined by the internal maxillary vein to form the posterior facial vein.

The **frontal** and **supraorbital veins** drain the blood from the anterior part of the scalp. At the medial commissure of the eyelids they unite to form the **angular vein,** which passes downwards to the lower margin of the orbit where it receives the name of the anterior facial vein. The frontal diploic vein opens into the supraorbital vein. The angular vein communicates with the superior ophthalmic vein through the nasofrontal vein and thus communication is effected between the cavernous sinus and anterior facial vein.

The **anterior facial vein** is the continuation of the angular vein. It runs behind its corresponding artery, the external maxillary, but follows a much straighter course. It crosses the masseter and the lower border of the mandible and lies superficial to the submaxillary gland. A little below the angle of the mandible it unites with the anterior branch of the posterior facial vein to form the common facial vein. The anterior facial vein communicates with the pterygoid venous plexus through the deep facial vein.

The **posterior facial vein** is formed by the union of the superficial temporal and internal maxillary veins. It descends through the substance of the parotid gland and emerging from the gland divides into two branches : the anterior branch unites with the anterior facial vein to form the **common facial vein** which crosses the external carotid artery and joins the internal jugular vein below the hyoid bone ; the posterior branch joins the posterior auricular vein to form the external jugular vein.

**Pterygoid plexus of veins** and the **internal maxillary vein** (Fig. 215).—Around the external pterygoid muscle is seen a plexus of veins called the *pterygoid plexus* into which the tributaries corresponding to the branches of the internal maxillary artery open. From this plexus proceeds a short venous trunk called the *internal maxillary vein* which accompanies the first portion of the internal maxillary artery. Passing through the parotid gland it unites behind the neck of the mandible with the superficial temporal vein to form the posterior facial vein (temporomaxillary vein). The pterygoid plexus communicates above with the cavernous sinus by emissary veins which pass through the foramen ovale, the foramen Vesalii and the foramen lacerum. In front it communicates with the anterior facial vein by the *deep facial vein* which proceeds forwards beneath the masseter muscle. It also communicates with the inferior ophthalmic vein in the orbit by a small branch which passes through the inferior orbital fissure.

## The Emissary and Diploic Veins

The **emissary veins** are veins which pass through apertures in the wall of the cranium and connect the venous sinuses in the interior of the cranium with the veins lying outside the wall of the cranium. They are set forth in the table below.

EMISSARY VEINS

| | | CONNECTS | THROUGH |
|---|---|---|---|
| 1. | Frontal .. | Veins of nose with superior sagittal sinus .. .. | Foramen cæcum |
| 2. | Parietal .. | Occipital veins with superior sagittal sinus .. .. | Parietal foramen |
| 3. | Mastoid .. | Posterior auricular or occipital vein with transverse sinus .. .. .. | Mastoid foramen |
| 4. | Condyloid .. | Veins in suboccipital triangle with transverse sinus .. | Condyloid foramen |
| 5. | Plexus of hypoglossal canal | Internal jugular vein with transverse sinus .. | Hypoglossal canal |
| 6. | Plexus of foramen ovale .. | Pterygoid plexus with cavernous sinus .. .. | Foramen ovale |
| 7. | Vein of foramen Vesalii .. | Pterygoid plexus with cavernous sinus .. .. | Foramen Vesalii |
| 8. | Veins of foramen lacerum | Pterygoid plexus with cavernous sinus .. .. | Foramen lacerum |
| 9. | Internal carotid plexus of veins | Internal jugular vein with cavernous sinus .. | Carotid canal |

The **diploic veins** are contained in bony channels in the spongy bone, called diploe, between the outer and inner tables of the cranial bones. They have no valves and their walls are thin. From the diploic spaces four diploic veins, on each side, emerge and are called the frontal, anterior and posterior temporal, and

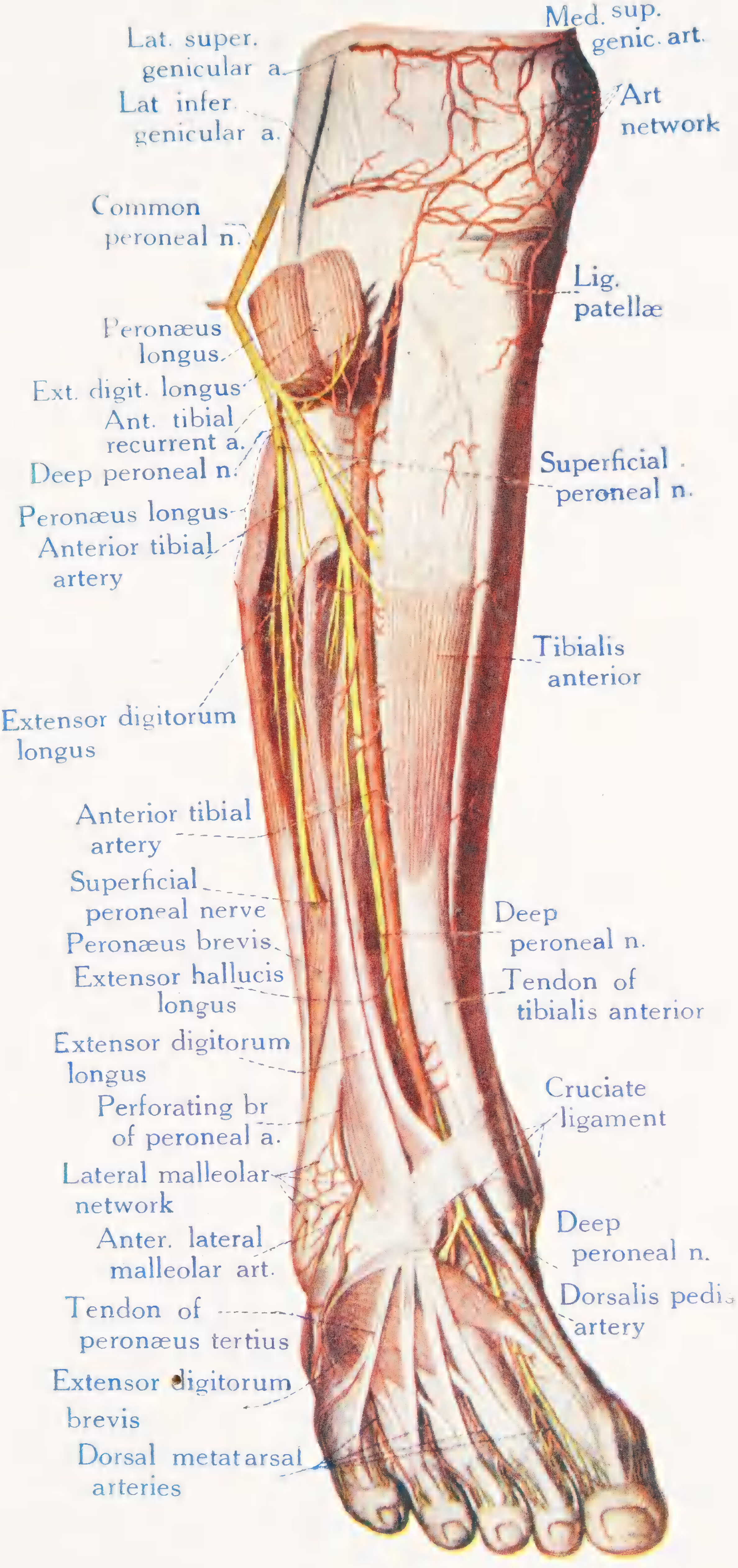

Fig. 241.—The anterior tibial and dorsalis pedis arteries.

To face p. 444.

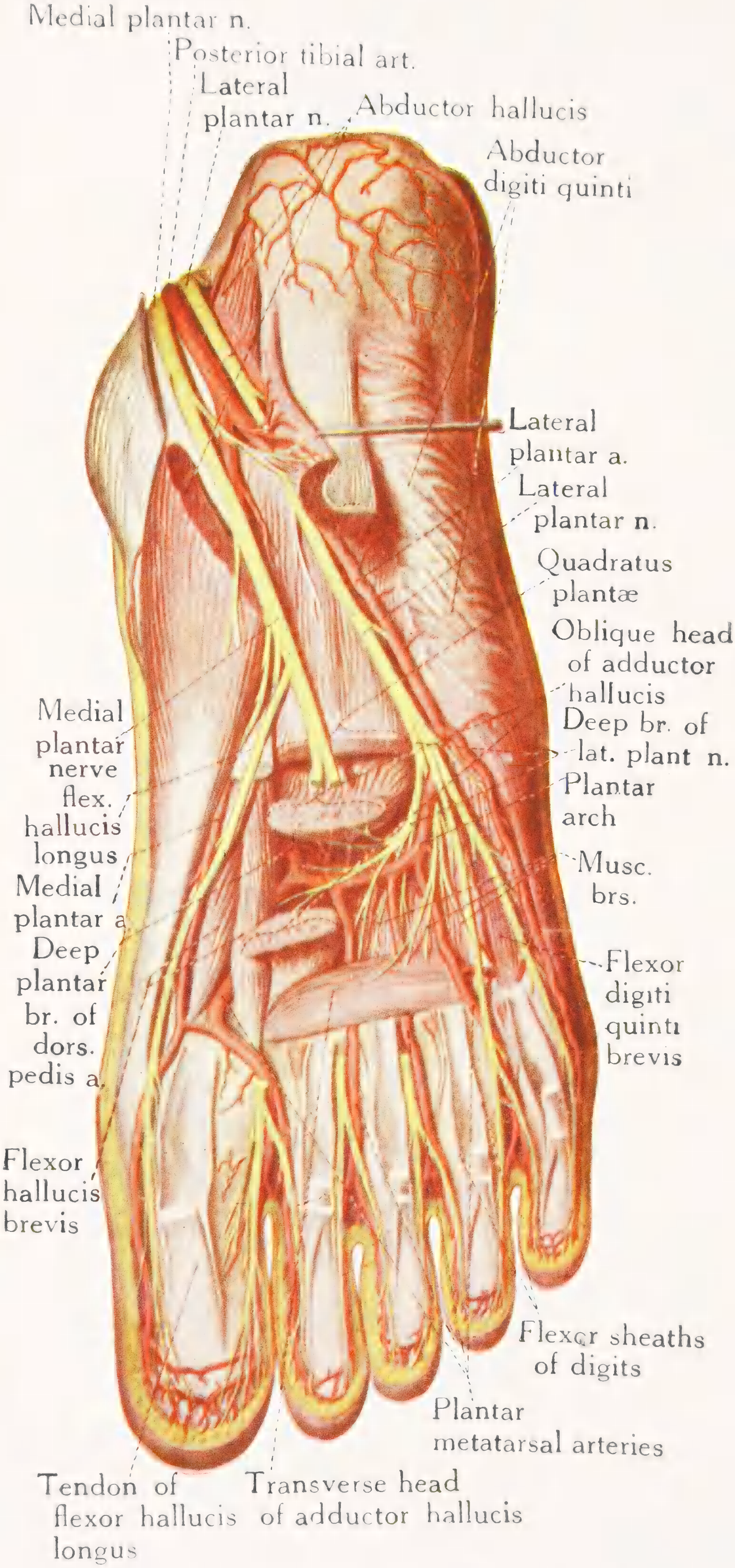

Fig. 242.—Deep dissection of the sole of the foot.

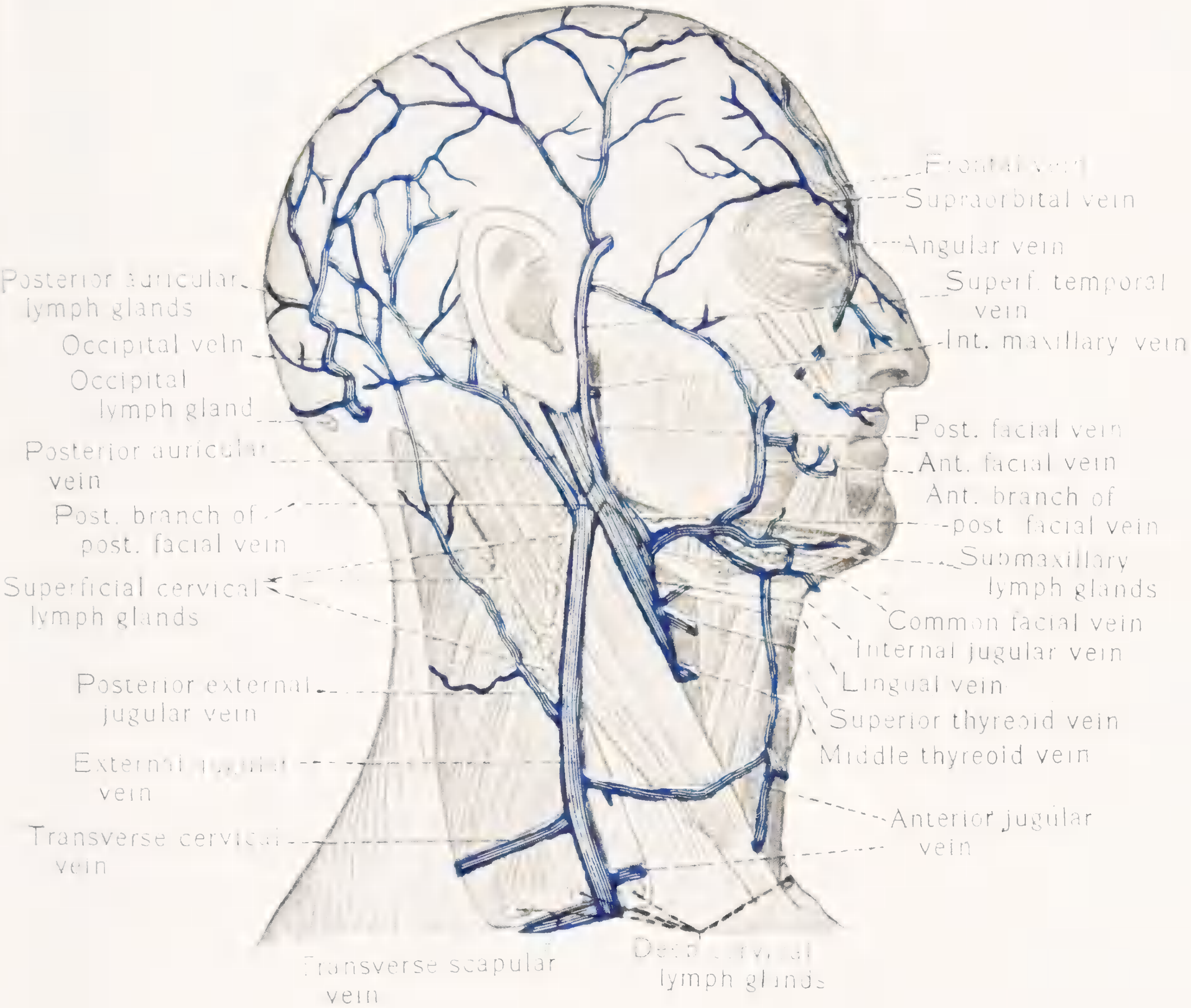

Fig. 243.—The veins and superficial lymph glands of the right side of the head and neck.

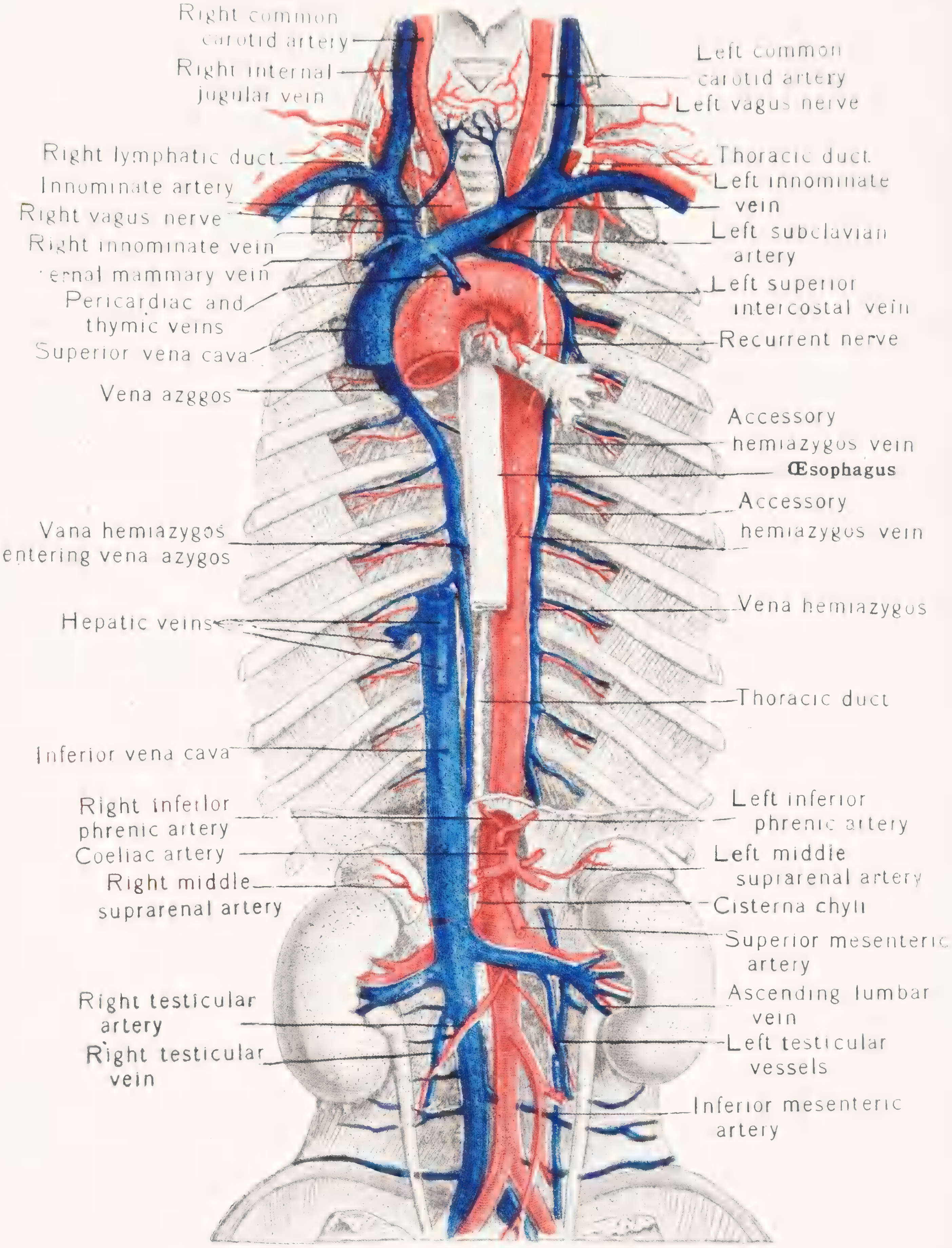
Right common carotid artery
Right internal jugular vein
Right lymphatic duct
Innominate artery
Right vagus nerve
Right innominate vein
ernal mammary vein
Pericardiac and thymic veins
Superior vena cava
Vena azggos
Vana hemiazygos entering vena azygos
Hepatic veins
Inferior vena cava
Right inferior phrenic artery
Coeliac artery
Right middle suprarenal artery
Right testicular artery
Right testicular vein
Left common carotid artery
Left vagus nerve
Thoracic duct
Left innominate vein
Left subclavian artery
Left superior intercostal vein
Recurrent nerve
Accessory hemiazygos vein
Œsophagus
Accessory hemiazygos vein
Vena hemiazygos
Thoracic duct
Left inferior phrenic artery
Left middle suprarenal artery
Cisterna chyli
Superior mesenteric artery
Ascending lumbar vein
Left testicular vessels
Inferior mesenteric artery

Fig. 245.—The superior and inferior venae covae, the innominate veins and the azygos veins.

To face p. 445.

occipital. The *frontal diploic vein* is contained in the anterior part of the frontal bone ; it emerges through a small aperture in the roof of the supraorbital notch and opens into the supraorbital vein. The *anterior temporal diploic vein* is contained in the posterior part of the frontal and anterior part of parietal bone ; it pierces the great wing of the sphenoid and opens into the sphenoparietal sinus or the anterior deep temporal vein. The *posterior temporal diploic vein* is contained in the posterior part of the parietal bone ; it passes usually through the mastoid foramen and opens into the transverse sinus. The *occipital diploic vein* is contained in the occipital bone ; it opens into the occipital vein or into the transverse sinus .

### The Venous sinuses of the Duramater and Meningeal Veins

The **venous sinuses** of the dura mater (Fig. 244) are venous channels caused by the separation of the two layers of dura mater in certain situations. They are lined by endothelium and have no valves. They communicate with the meningeal veins and with the veins on the exterior of the cranium. They receive the veins of the brain and terminate in the internal jugular vein directly or indirectly. The venous sinuses of the dura mater may be arranged as follows :—

A. *Along the median plane.*
- Superior sagittal.
- Inferior sagittal.
- Straight.
- Occipital.

B. *Bilateral.*
- Transverse.
- Cavernous.
- Sphenoparietal.
- Superior petrosal.
- Inferior petrosal.

C. *Across the median plane.*
- Intercavernous.
- Basilar plexus.

The **superior sagittal sinus** (superior longitudinal sinus) is a venous channel situated along the convex margin of the falx cerebri. It extends from the foramen cæcum in front to the internal occipital protuberance behind, grooving the inner surfaces of the cranial bones along the middle line of the vertex of the skull. The lumen of the sinus is triangular, small in front and gradually increases in size behind. Slender fibrous bands called *chordae Willisii* traverse the sinus at its inferior angle. On either side of the sinus are seen recesses, called *venous lacunae,* which exist between the two layers of the dura mater and open into the sinus ; many cerebral veins open into these lacunæ. The arachnoidean granulations project into the sinus and lacunæ. In connection with the superior sagittal sinus, an *emissary vein* passes through the foramen cæcum connecting the front part of the sinus with the veins of the nasal fossæ. Two other emissary veins pass through the parietal foramina and connect the sagittal sinus with the occipital veins in the scalp. The superior cerebral veins are the tributaries of the superior sagittal sinus. The superior sagittal sinus is usually continuous with the right transverse sinus.

The **inferior sagittal sinus** (inferior longitudinal sinus) is situated in the free margin of the falx cerebri at its posterior

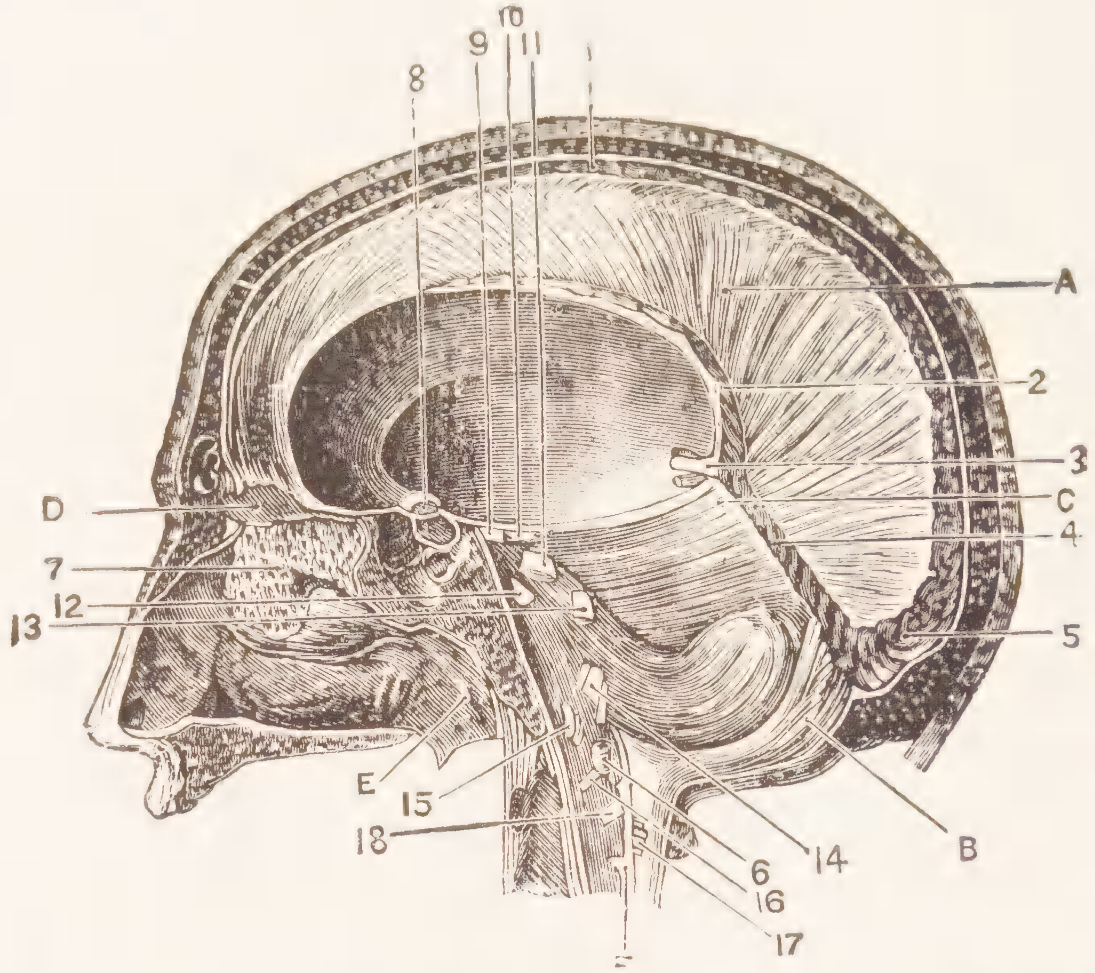

Fig. 244.—Processes and sinuses of the dura mater; exit of the cerebral nerves. Sideview.

A. Falx cerebri.
B. Falx cerebelli.
C. Tentorium cerebri.
D. Crista galli of ethmoid.
E. Auditory tube.
F. Ligamentum denticulatum.
1. Superior sagittal sinus.
2. Inferior sagittal sinus.
3. Great cerebral vein.
4. Straight sinus.
5. Confluence of sinuses.
6. Vertebral artery.
7. Olfactory nerves.
8. Optic nerve.
9. Oculomotor nerve.
10. Trochlear nerve.
11. Trigeminal nerve.
12. Abducent nerve.
13. Facial and acoustic nerves.
14. Glossopharyngeal, vagus and accessory nerves.
15. Hypoglossal nerve.
16. First cervical nerve.
17. Posterior root of second cervical nerve.
18. Anterior root of second cervical nerve.

half or two-thirds. It receives tributaries from the falx cerebri and a few veins from the medial surface of the cerebral hemispheres. It terminates behind at the anterior extremity of the straight sinus.

The **straight sinus** passes from before backwards along the line of union between the tentorium cerebelli and the falx cerebri. At the internal occipital protuberance it terminates in the transverse sinus of the side (usually the left) that does not receive the superior sagittal sinus. Its tributaries are: (1) the inferior sagittal sinus, (2) the great cerebral vein which opens at its front, and (3) the superior cerebellar veins.

The **transvere sinuses** (lateral sinuses) are two in number, a right and a left. The right one is usually a continuation of the superior sagittal sinus while the left one, of the straight sinus. Sometimes the superior sagittal sinus is continued into the left transverse sinus, and the straight sinus into the right transverse sinus. At the beginning of the transverse sinus where the superior sagittal sinus opens there is a dilatation called the *confluence of sinuses* (torcular Herophili). The confluence is lodged in a depression at one side (usually the right) of the internal occipital protuberance; from it the transverse sinus of the same side begins and into it the occipital sinus terminates. Sometimes the two transverse sinuses at their commencement communicate with each other by a short transverse venous channel passing in front of the internal occipital protuberance. Each sinus passes lateralwards and forwards lying against the inner surface of the occipital bone and the mastoid angle of the parietal bone along the attached border of the tentorium cerebelli. It then curves downwards and medialwards lying along the sigmoid sulcus of the mastoid portion of the temporal bone; this part is known as the *sigmoid sinus*. It then rests on the upper surface of the jugular process of the occipital bone. Finally it passes through the posterior compartment of the jugular foramen to become continuous with the internal jugular vein. Its tributaries are (1) some cerebellar veins, (2) a diploic vein, and (3) the superior petrosal sinus. It communicates with the extra-cranial veins by two emissary veins, one of which passes through the mastoid foramen and the other through the condyloid canal. The former establishes communication with the posterior auricular veins and the latter with the deep venous plexuses in the suboccipital region.

The **occipital sinus** lies along the posterior border of the falx cerebelli. It begins by small veins around the foramen magnum and ends in the confluence of sinuses. Usually there are two occipital sinuses at the commencement which unite higher up to form a single channel. Sometimes they remain separate in their entire course and each opens into the transverse sinus of its own side. It communicates below with the posterior internal vertebral venous plexus.

**Cavernous sinus.**—This is a curved sinus so called because its lumen is traversed by intersecting bands. It lies on either side of the body of the sphenoidal bone. It begins in front at the superior orbital fissure where it receives the ophthalmic veins and ends behind at the apex of the petrous portion of the temporal bone into the superior and inferior petrosal sinuses. On the lateral wall of the sinus are the oculomotor, the trochlear, the ophthalmic and maxillary divisions of the trigeminal nerve; on the medial wall is the internal carotid artery surrounded by filaments of the carotid plexus of sympathetic; the abducent nerve runs forwards lateral to the artery. It communicates with its fellow of the opposite side by the intercavernous sinuses. In addition to the ophthalmic veins the other tributaries of the cavernous sinus are the middle cerebral vein, inferior cerebral veins, and sphenoparietal sinus. Two emissary veins, one passing through the foramen ovale or foramen Vesalii and the other through the foramen lacerum, connect the cavernous sinus with the pterygoid plexus of veins outside the cranial cavity. The internal carotid plexus of veins accompanying the internal carotid artery also opens into the cavernous sinus and thus establishes communication with the pharyngeal venous plexus in the neck. The cavernous sinus also communicates by means of superior petrosal sinus with the transverse sinus, by the inferior petrosal sinus with the internal jugular vein, and by the superior ophthalmic vein with the angular vein.

The **sphenoparietal sinus** is a minute venous channel which passes medialwards along the under surface of the small wing of the sphenoidal bone and opens into the cavernous sinus.

The **superior petrosal sinus** begins at the posterior end of the cavernous sinus and ends in the transverse sinus. It lies in a groove along the superior border of the petrous portion of the temporal bone, along the attached margin of tentorium cerebelli.

The **inferior petrosal sinus** runs along the groove formed by the articulation of the basilar part of the occipital bone with the posterior border of the petrous portion of the temporal bone. It begins in front in the cavernous sinus and ends behind in the internal jugular vein, after passing through the anterior compartment of the jugular foramen.

The **intercavernous sinuses**, two in number, an anterior and a posterior, connect the cavernous sinuses ; the anterior passing in front and the posterior behind the diaphragma sellæ. The two intercavernous sinuses together with the intervening cavernous sinuses form a circular venous channel called the *circular sinus*.

The **basilar plexus** consists of minute venous channels between the two layers of the dura mater covering the basilar part of the occipital bone and establishes communication between the inferior petrosal sinuses of the two sides. Below it communicates with the anterior internal vertebral venous plexus.

The **meningeal veins** begin in a superficial and a deep plexus The deep plexus lies in the inner layer of the duramater and its efferent veins end in the superficial plexus. The superficial plexus occupies the outer layer of the duramater ; its efferents are of two kinds : (1) some open into the venous sinuses of the duramater, (2) others accompany the meningeal arteries. The vein accompanying the middle meningeal artery is called the *middle meningeal vein* or *sinus* ; it divides into two trunks of which the anterior passes through the foramen ovale and the posterior through the foramen spinosum ; both end in the pterygoid venous plexus.

## The Veins of the Orbit

The **ophthalmic veins** are two in number, superior and inferior. The *superior ophthalmic vein* begins at the medial angle of the orbit as the nasofrontal vein which communicates with the angular vein. It accompanies the ophthalmic artery and receives tributaries corresponding to the branches of the artery; it passes backwards between the two heads of the rectus lateralis and through the superior orbital fissure and opens into the cavernous sinus. The *inferior ophthalmic vein* is formed at the front part of the floor of the orbit by some minute veins. It runs backwards below the eyeball and the optic nerve, receives some tributaries, and divides into two branches. One of these communicates with the pterygoid venous plexus through the inferior orbital fissure and the other passes through the superior orbital fissure and ends in the cavernous sinus either directly or in common with the superior ophthalmic vein.

## The Veins of the Brain

The **veins of the brain** comprise the veins of the cerebrum, of the cerebellum, of the pons, and of the medulla oblongata. They present the following peculiarities: (1) They have very thin walls, no muscular tissue, and no valves; (2) they do not accompany the cerebral arteries; (3) they all terminate in the sinuses of the dura mater. The cerebral veins are divisible into two groups, external and internal. The former drain from the outer surface and the latter from the inner surface of the cerebrum. The **external group of cerebral veins** are (1) superior, (2) middle, (3) inferior and (4) basal. The *superior cerebral veins* are six to twelve in number. They drain the venous blood from the medial surface and from the upper part of the lateral surface of the cerebral hemisphere and open into the superior sagittal sinus. The anterior veins of this group open at right angles to the sinus and the posterior ones open obliquely forwards into the sinus against the current of blood in it. The *middle cerebral vein* receives venous blood from the lower part of the lateral surface of the cerebral hemisphere and courses along the lateral cerebral fissure from behind forwards to terminate in the cavernous sinus. It communicates with one of the superior cerebral veins by means of a venous channel, called the *great anastomotic vein*, and thus indirectly communicates with the sagittal sinus. Behind it also communicates with the transverse sinus by a vein, called the *posterior anastomotic vein*, which runs over the temporal lobe. The *inferior cerebral veins* are of small size. Those from the orbital surface of the frontal lobe open either into the anterior cerebral vein or into the middle cerebral vein. Those from the temporal lobe open into the basal vein or into the superior petrosal sinus or the transverse sinus. The *basal vein* is formed by the union of the anterior cerebral vein and deep middle cerebral vein at the anterior perforated substance. It is joined by an internal vein, viz., the *inferior striate vein*, which emerges from the anterior perforated substance. The basal vein passes backwards round the cerebral peduncle and opens into the internal cerebral vein. The *anterior cerebral vein* receives venous blood from the medial surface of the cerebral hemisphere. It issues from the anterior part of the longitudinal fissure and proceeds to the anterior perforated substance where it opens into the basal vein. The *deep middle cerebral vein* drains venous blood from the insula. It courses along the lateral cerebral fissure and opens into the basal vein at the anterior perforated substance.

The **internal group of cerebral veins** are : (1) The *great cerebral vein* (vena magna Galeni) is the large vein which drains venous blood from the interior of the cerebrum. It is formed by the union of the two internal cerebral veins beneath the corpus callosum between the two layers of the tela chorioidea of the third ventricle. It issues beneath the posterior end of the corpus callosum and opens into the anterior end of the straight sinus. (2) The *internal cerebral veins* are two in number ; each is formed by the union of the terminal and chorioid veins near the interventricular foramen and passes backwards between the two layers of the tela chorioidea of the third ventricle to meet its fellow of the opposite side forming the great cerebral vein. The *terminal vein* lies in the groove between the corpus striatum and the thalamus ; it receives tributaries which issue from both these structures. The *chorioid vein* runs along the whole length of the chorioid plexus and receives tributaries which issue from the hippocampus, the fornix and corpus callosum.

The **cerebellar veins** may be grouped into two sets, the superior and inferior. The *superior cerebellar veins* pass forwards and medialwards and open into the straight sinus and into the great cerebral vein. Some pass lateralwards to open into the superior petrosal sinus or transverse sinus. The *inferior cerebellar veins* drain the inferior surface of the cerebellum and open into the occipital, transverse and superior petrosal sinuses.

The **veins of the pons** pass upwards to end in the basal vein. The **veins of the medulla oblongata** converge to two trunks, an anterior and a posterior median vein. The *anterior median vein* communicates with the veins of the pons above and those of the medulla spinalis below. The *posterior median vein* also communicates below with the veins of the spinal medulla but terminates above in the inferior petrosal sinus or basilar plexus.

## The Veins of the Neck (Fig. 243)

The veins of the neck are subdivided into a superficial and a deep group. The superficial veins are : (1) the anterior jugular, (2) the external jugular, and (3) the posterior external jugular. The deep veins are (1) the internal jugular, (2) vertebral, and (3) the subclavian.

The **anterior jugular vein** is formed in the submaxillary region by the union of some small superficial veins. It runs down vertically close to the middle line of the neck. Above the medial end of the clavicle the vein pierces the deep fascia, proceeds lateralwards beneath the sternocleidomastoideus and opens either into the external jugular or into the subclavian vein. Above the sternum and between the two layers of the fascia colli, a communication takes place between the anterior jugular veins of the two sides by a transverse branch called the *venous jugular arch.* The anterior jugular vein may be absent on one side. Its size varies inversely with that of the external jugular vein.

The **external jugular vein** is formed by the union of the posterior auricular vein and the posterior branch of the posterior facial vein in the substance of the parotid gland just behind the angle of the mandible. It runs down vertically along a line drawn from the angle of the lower jaw to the middle of the clavicle, crossing obliquely in its course the sternocleidomastoideus. It pierces the deep fascia of the neck above the clavicle to open into the subclavian vein. While on the surface of the sternocleidomastoideus it lies parallel with the great auricular nerve and crossing the nervus cutaneous colli it descends to lie in front of the third part of the subclavian artery before it terminates in the subclavian vein. The external jugular vein lies closely related to four or six lymph glands, called the superficial cervical lymph glands. *Tributaries.*—Above, in the substance of the parotid gland it communicates by a branch with the internal jugular vein ; in the middle of its course it receives the posterior external jugular vein from the occipital region ; and lower down before opening into the subclavian vein it receives the transverse cervical, transverse scapular, and anterior jugular veins.

The **posterior external jugular vein** begins in the upper and back part of the neck, runs downwards and forwards and opens about the middle part of the external jugular vein.

The **internal jugular vein** is the continuation of the transverse sinus, which leaves the cranial cavity through the posterior compartment of the jugular foramen. At its commencement it presents a dilatation called the *superior bulb.* At first it lies upon the rectus capitis lateralis and behind the internal carotid artery ; the lower four cerebral nerves intervening between the artery and the vein. Then it descends on the lateral side of the artery under cover of the sternocleidomastoideus up to the upper border of the thyreoid cartilage. Below the cartilage it lies to the lateral side of the common carotid artery. Throughout its whole course in the neck it is contained within the carotid sheath with the common or internal carotid artery lying to its medial side and the vagus nerve between and behind the artery and the vein. Finally it unites with the subclavian vein to form the innominate vein behind the medial end of the clavicle. Before its termination it presents another dilatation called the *inferior bulb.* A pair of valves is seen inside the vein about an inch above its termination. In front of and behind the vein are found the superior deep cervical lymph glands.

The **tributaries** of the internal jugular vein are : (1) the inferior petrosal sinus, (2) the common facial, (3) lingual veins,

(4) the pharyngeal, (5) the superior and middle thyreoid veins, and (6) sometimes the occipital vein. The thoracic duct opens into the left internal jugular vein at its union with the left subclavian vein, and the right lymphatic duct into the right internal jugular vein at its union with the right subclavian vein.

The **lingual veins** return blood from the tongue, accompany the lingual artery and end in the internal jugular vein. The *vena comitans hypoglossi* accompanies the hypoglossal nerve and often ends in the internal jugular vein. The **pharyngeal veins** begin from the venous plexus on the outer wall of the pharynx and end in the internal jugular vein. The **superior thyreoid vein** receives tributaries from the upper part of the thyreoid gland, accompany the superior thyreoid artery and ends in the upper part of the internal jugular vein. The **middle thyreoid vein** receives tributaries from the lower part of the thyreoid gland and ends in the lower part of the internal jugular vein. The inferior thyreoid veins are described on p. 454.

**Vertebral vein.**—There is no companion vein corresponding to the fourth or intracranial part of the vertebral artery. A venous plexus is formed round the third part of the artery by the union of veins derived from the venous plexus in the suboccipital triangle and the venous plexus in the vertebral canal. This plexus descends through the foramina transversaria of the cervical vertebræ in company with the second part of the artery and ultimately terminates in a single vein, the vertebral vein, which emerges from the foramen in the transverse process of the sixth cervical vertebra and opens into the upper and posterior part of the innominate vein. Its termination is provided with a valve. Its *tributaries* are: (1) branches from the occipital vein and from the internal and external vertebral venous plexuses; (2) ascending cervical vein; (3) deep cervical vein. The vertebral vein is connected with the transverse sinus of the skull by an emissary vein which passes through the condyloid canal.

The **ascending cervical vein** begins in a plexus formed on the anterior aspects of the bodies and transverse processes of the cervical vertebræ. It accompanies the ascending cervical artery and terminates in the lower part of the vertebral vein.

The **deep cervical vein** begins from a venous plexus in the suboccipital triangle and descends in company with its artery, the profunda cervicis artery, and opens into the lower part of the vertebral vein.

The **subclavian vein** (Fig. 245) is the continuation of the axillary vein. It begins at the outer border of the first rib and ends behind the medial end of the clavicle by joining the internal jugular vein to form the innominate vein. It is in relation in front with the coracoclavicular fascia which separates it from the subclavius, and with the back of the medial end of the clavicle from which it is separated by the fibres of the sternohyoid and sternothyreoid. Below it lies upon a groove on the first rib and upon the pleura. Above and behind it is the subclavian artery from which it is separated by the scalenus anterior and the phrenic nerve. It is provided with a pair of valves which is situated near the opening of the external jugular vein. Its *tributary* is the external jugular vein. Into the angle of union of the subclavian and internal jugular veins on the right side, the right lymphatic duct opens ; and in the corresponding place on the left side, the thoracic duct ends.

## THE VEINS OF THE THORAX

The **innominate veins** (Fig. 245) are two in number, a right and a left. They are formed behind the sternal ends of the clavicles by the union of the internal jugular and subclavian veins. The two innominate veins unite together behind the first right costal cartilage close to the sternum and form the superior vena cava.

The **right innominate vein** is about 1 inch in length. It passes downwards and slightly medialwards and unites with the left innominate vein to form the superior vena cava. On its *right side* is the right phrenic nerve. On its *left side* is the innominate artery. *In front* it is covered by pleura and *behind* it is the right vagus nerve.

The **left innominate vein** is about 3 inches in length. It passes obliquely downwards and to the right to unite with the right innominate vein. *In front* of it are the sternohyoid and sternothyreoid muscles and the remains of the thymus gland. *Behind* it are the left pleura, the left internal mammary artery the innominate, left common carotid and left subclavian arteries, and the left vagus and phrenic nerves and the trachea. *Below* it is the arch of the aorta.

**Tributaries** of the right and left innominate veins.—

| The right innominate vein receives :— | The left innominate vein receives :— |
|---|---|
| 1. The right vertebral vein. | 1. The left vertebral vein. |
| 2. The right internal mammary vein. | 2. The left internal mammary vein. |
| 3. The right inferior thyreoid vein. | 3. The left inferior thyreoid vein. |
| 4. The first right intercostal vein. | 4. The first left intercostal vein. |
| | 5. The left superior intercostal vein. |
| | 6, 7. Some pericardiac and thymic veins. |

The **internal mammary veins** are venæ comites of the internal mammary artery. They receive tributaries corresponding to the branches of the artery and, at the upper part of the thorax, unite to form a single trunk which opens into the corresponding innominate vein.

The **left superior intercostal vein** is formed by the union of the second, third and sometimes the fourth intercostal veins of the left side. It runs obliquely upwards and forwards and terminates in the left innominate vein.

The **inferior thyreoid veins** commence from the venous plexus in the thyreoid gland. The two veins, right and left, descend along the front of the trachea and terminate in the innominate vein of its own side.

The **bronchial veins** appear at the root of the lung as two trunks on either side ; those of the right side open into the azygos vein ; those of the left side open into the accessory hemiazygos vein or into the left superior intercostal vein.

The **intercostal veins** (Figs. 232, 245) are also called the *posterior intercostal veins* to differentiate them from the *anterior intercostal veins* which are tributaries of the internal mammary and musculophrenic veins. They are eleven in number on each side. There is a single vein in each space which is placed above the corresponding artery in the costal groove. On the *right side* the first intercostal vein, called the highest intercostal vein, terminates usually in the right innominate vein. The second and third intercostal veins of the right side unite to form the *right superior intercostal vein* which opens into the azygos vein. The remaining right intercostal veins open separately into the azygos vein. On the *left side* the highest intercostal vein opens usually into the left innominate vein. The *left superior intercostal vein,* formed by the union of the second and third intercostal veins of the left side, opens into the left innominate vein. The fourth, fifth, sixth, seventh and eighth intercostal veins of the left side end in the accessory hemiazygos vein and the ninth, tenth, and eleventh intercostal veins end in the hemiazygos vein.

The **subcostal vein** accompanies the subcostal artery ; that of the right side opens into the azygos vein and that of the left side into the hemiazygos vein.

The **azygos vein** (vena azygos major) (Figs. 232, 245) is the continuation upwards of the right ascending lumbar vein at the level of the first or second lumbar vertebra. It lies between the cisterna chyli and the right crus of the diaphragm and enters the thorax through the aortic opening of the diaphragm with the thoracic duct. Then it ascends along the right side of the vertebral column to the posterior aspect of the root of the right lung ; thereafter it arches anteriorly above the root to open into the superior vena cava before that vessel pierces the pericardium. In its course it lies upon the right intercostal arteries and is placed on the right side of the thoracic duct and the thoracic portion of the descending aorta.

*Tributaries.*—The azygos vein receives (1) the right subcostal vein, (2) the lower eight intercostal veins of the right side, (3) the right superior intercostal vein, (4) the hemiazygos vein, (5) the accessory hemiazygos vein, (6) the right bronchial veins, (7) the œsophageal veins, and (8) the pericardiac veins.

The **hemiazygos vein** (vena azygos minor inferior) (Fig. 245) begins in the abdomen as the left ascending lumbar vein. It enters the thorax through the left crus of the diaphragm and ascends to the level of the eighth thoracic vertebra along the left side of the vertebral column, crossing the left intercostal arteries in its course. Then it crosses the vertebral column from the left to the right behind the descending aorta, the thoracic duct and the œsophagus and opens into the azygos vein. Its *tributaries* are the left subcostal vein, the lower three or four left intercostal veins and sometimes the accessory hemiazygos vein.

The **accessory hemiazygos vein** (vena azygos minor superior) Fig. 245) is formed usually by the veins from the fourth to the eighth intercostal spaces of the left side. It descends along the left side of the vertebral column and at the level of the seventh thoracic vetebra crosses to the right to open into the azygos vein or sometimes into the hemiazygos vein.

The **superior vena cava** (Fig. 245) is a short trunk about 3 inches in length and is destitute of valves. It drains blood from the head and neck, superior extremities, thoracic and upper portion of the abdominal wall. It is formed behind the first right costal cartilage close to the sternum by the union of the two innomiate veins. It descends vertically, pierces the pericardium and opens into the upper and back part of the right atrium behind the third costal cartilage. In the *upper half* of its course it lies in the superior mediastinal space ; in the *lower half* of its course, it is enclosed within the fibrous layer of the pericardium and lies in the middle mediastinal space ; the serous layer of the pericardium covers this portion in front and at the sides. *Relations.* —The anterior margin of the right lung and pleura and ascending aorta lie *in front* of it ; the trachea, right vagus nerve, azygos vein, right bronchus, right pulmonary artery and upper right pulmonary vein lie *behind* it ; the right mediastinal pleura and the right phrenic nerve being placed on its *right side* ; while on its *left side,* are the ascending aorta and the innominate artery.

**Tributaries.**—The superior vena cava receives the two innominate veins, at its commencement the azygos vein immediately before it pierces the pericardium, and several small mediastinal and pericardiac veins.

### **The Veins of the Vertebral Column** (Fig. 246)

The veins around and within the vertebral column extending from the cranium to the coccyx exist as two groups of plexuses, an external and an internal vertebral venous plexus. These plexuses communicate with each other and open into the intervertebral veins. The external vertebral venous plexuses are anterior and posterior. The internal vertebral venous plexuses are also anterior and posterior.

The *anterior external vertebral venous plexuses* are formed on the anterior surfaces of the bodies of the vertebræ ; they communicate with the basivertebral and intervertebral veins.

The *anterior internal vertebral venous plexuses* consist of two longitudinal venous trunks one on either side of the posterior longitudinal ligament of the vertebræ. They communicate (1) with each other opposite the body of each vertebra by a transverse branch which is covered by the posterior longitudinal ligament and into which the basivertebral vein opens. Above they communicate (2) with the basilar plexus or with the occipital sinus and behind (3) with the posterior internal vertebral venous plexus. Laterally they send off branches towards the intervertebral foramina which join with similar branches from the posterior venous plexus to form the *intervertebral veins*. These intervertebral veins open into the vertebral veins in the neck, into the intercostal veins in the thorax, into the lumbar veins in the lumbar region, and into the lateral sacral veins in the sacral region.

The *posterior internal vertebral venous plexuses* consist of two longitudinal plexuses one on either side of the middle line situated between the laminæ and ligamenta flava behind, and the dura mater covering the medulla spinalis in front. They communicate (1) with each other by transverse branches, (2) with the posterior external vertebral venous plexuses outside the canal by branches passing through the ligamenta flava, (3) with the anterior internal vertebral venous plexuses in front, and (4) with the occipital sinus above. They send laterally branches which unite with similar branches from the anterior internal vertebral venous plexuses to form intervertebral veins.

The *posterior external vertebral venous plexuses* are networks of veins situated on the external surfaces of the laminæ, the spinous, the articular and the transverse processes of the vertebræ. These plexuses receive blood from the skin and muscles of the back, and end in the intercostal veins in the thoracic region, in the lumbar veins in the lumbar region, and in the vertebral veins in the cervical region.

The *basivertebral veins* occupy the interior of the bodies of the vertebræ and are like the diploic veins of the cranial bones. They communicate in front with the anterior external vertebral plexuses and behind with the transverse branches connecting the two anterior internal vertebral plexuses.

The **veins of the medulla spinalis** form plexuses on the surface of the medulla spinalis. Six longitudinal trunks are found amongst these plexuses; one runs along the anteromedian fissure beneath the arterial trunk. Another runs along the posteromedian fissure. The other four run laterally, two on each side, one in front of and the other behind the posterior nerve roots. These trunks communicate freely with each other and send branches laterally along the nerve roots to join the internal vertebral venous plexuses.

## THE VEINS OF THE ABDOMEN AND PELVIS (Figs. 236, 245)

The **inferior vena cava** (Figs. 233, 245) is the large venous channel which returns the blood from the lower extremities, from the lower part of the abdominal wall and from the contents of the abdomen and pelvis. It is formed by the union of the two common iliac veins on the body of the fifth lumbar vertebra, It ascends on the bodies of the vertebræ along the right side of the abdominal aorta and reaches the liver. It is then lodged in a deep groove, the fossa of the inferior vena cava,on the posterior surface of that organ. As it leaves the liver it pierces the central tendon of the diaphragm at the junction of the right and middle leaflets. It then lies in the middle mediastinum, pierces the fibrous pericardium and opens into the lower and posterior part of the right atrium. The inferior vena cava thus consists of an abdominal portion and a thoracic portion.

The **abdominal portion** of the inferior vena cava is in relation *in front* with the right common iliac artery, the lower end of the mesentery,the right testicular artery, the horizontal part of the duodenum, the head of the pancreas, the epiploic foramen, the portal vein, and the posterior surface of the liver—in that order from below upwards. *Behind* it, are the bodies of the lower lumbar vertebræ, the right psoas major, the right inferior phrenic, suprarenal, renal and lumbar arteries, the right crus of the diaphragm, the right sympathetic trunk, right cœliac ganglion and the right suprarenal gland. On its *right side* are the right ureter and the right kdney. On its *left side* are the aorta and the right crus of the diaphragm.

The **thoracic portion** is very short, about 1 inch in length, and lies partly within the pericardium and partly outside it. The *extrapericardial portion* is separated from the right lung by the right phrenicopericardiac ligament which stretches from the pericardium to the caval orifice in the diaphragm. The *intrapericardial portion* is covered on the front and sides by the parietal portion of the serous layer of the pericardium ; its atrial orifice gives attachment by its margin to the valve of the inferior vena cava.

The **tributaries** of the inferior vena cava are : the two common iliac, lumbar, right testicular or ovarian, renal, right suprarenal, right inferior phrenic, and hepatic veins.

The **common iliac veins** (Fig. 233) are formed by the union of the external iliac and hypogastric veins in front of the sacroiliac articulation. Both veins pass upwards and unite on the right side of the fifth lumbar vertebra to form the inferior vena cava. The *right common iliac vein* is placed at first behind and then lateral to the companion artery. The *left common iliac vein* is longer than the right, and in its very oblique course from left to right is crossed by the superior hæmorrhoidal vessels. It lies at first to the medial side of its companion artery and then passes behind the right common iliac artery. *Tributaries.*—Each common iliac vein receives the iliolumbar vein and the left common iliac vein receives in addition the middle sacral vein. There is a single *iliolumbar vein* on each side ; it accompanies the corresponding artery. The venæ comites of the middle sacral artery unite above to form a single vein called the *middle sacral vein.*

The **lumbar veins** are usually four in number on each side, one with each lumbar artery. All the lumbar veins are connected by a longitudinal vein called the *ascending lumbar vein.* The right ascending lumbar vein terminates in the azygos and the left in the hemiazygos vein.

The **testicular veins** issue from the testis and epididymis as eight or ten veins and form a plexus called the *pampiniform plexus* which is one of the constituents of the spermatic cord. The plexus passes along the inguinal canal and near the abdominal inguinal ring terminates in two main trunks which proceed along with the corresponding testicular artery. The two veins finally unite to form a single terminal vein which opens on the right side into the inferior vena cava and on the left side into the left renal vein.

The **ovarian veins** issue from the hilum of the ovary and pass between the layers of the broad ligament where they form the *pampiniform plexus.* From the plexus two trunks issue which proceed along with the corresponding ovarian artery. Their subsequent course and termination are like those of the testicular veins.

**Renal veins.**—Each renal vein is formed by the union of four or five tributaries which emerge from the hilum of the kidney. The *right renal vein* is about 1 inch in length, passes behind the descending portion of the duodenum and opens into the right side of the inferior vena cava. The *left renal vein* is about 3 inches long and passes in front of the aorta immediately below the origin of the superior mesenteric artery and opens into the left side of the inferior vena cava at a higher level than the right ; it receives the left testicular (or ovarian) vein, the left suprarenal vein and the left inferior phrenic vein.

**Suprarenal veins.**—One suprarenal vein emerges from the hilum of each suprarenal gland. The right vein opens into the inferior vena cava ; the left opens into the left renal vein.

The **inferior phrenic veins** issue from the substance of the diaphragm and follow the course of the inferior phrenic arteries ; the right vein opens into the inferior vena cava ; the left vein usually opens into the left renal vein.

The **hepatic veins** convey blood which has passed through the liver from the portal vein and from the hepatic artery. They open into that portion of the inferior vena cava which lies in the groove on the posterior surface of the liver. They consist of two groups : an upper and a lower. The upper group consists of two veins, a right and a left ; sometimes a third vein, the middle vein, issues from the caudate lobe. The lower group consists of about 12 small-sized veins which issue from the right and caudate lobes. The hepatic veins, as they lie embedded in the liver substance, have been described on p. 326.

The **external iliac vein** is the continuation of the femoral vein and has an extent like the companion artery. It begins behind the inguinal ligament and passes upwards along the brim of the lesser pelvis to a point opposite the sacroiliac joint where it joins the hypogastric vein to form the common iliac vein. It lies at first medial to and then behind its companion artery on the right side ; on the left side it lies on the medial side of the artery throughout its course. The inferior epigastric, deep circumflex iliac and pubic veins open into it.

The **hypogastric vein** (internal iliac vein) is formed by tributaries corresponding to the branches of the hypogastric artery except the umbilical and iliolumbar branches. It commences at the upper part of the greater sciatic foramen and ascends behind its companion artery to the brim of the pelvis minor where it unites with external iliac vein to form the common iliac vein. Its *tributaries* are : (I) obturator, internal pudendal, and superior and inferior gluteal veins, which take their origins outside the pelvis ; (II) the vesical, middle hæmorrhoidal, uterine, and vaginal veins which take their origins within the pelvis as efferent veins from the plexuses around the pelvic viscera ; (III) the lateral sacral veins.

The **obturator vein** begins by the union of tributaries from the upper portion of the medial side of the thigh and enters the pelvis through the obturator canal. As it crosses the side of the pelvis it lies below the obturator artery and passing between the hypogastric artery laterally and ureter medially, it ends in the hypogastric vein.

The **internal pudendal veins** are the venæ comites of the internal pudendal artery and begin in the pudendal plexus. They accompany the internal pudendal artery and join to form a single vein which opens into the hypogastric vein. Their tributaries are the veins from the urethral bulb, the perineal and inferior hæmorrhoidal veins.

The **superior gluteal veins** (gluteal veins) are the venæ comites of the superior gluteal artery. They accompany the artery and open into the hypogastric vein.

The **inferior gluteal veins** (sciatic veins) are the venæ comites of the inferior gluteal artery. They accompany the artery and join to form a single vein which opens into the hypogastric vein.

The **superior vesical plexus** surrounds the fundus and sides of the bladder and lies in the muscular coat of the bladder. Its efferent veins open, in the male, into the prostaticovesical plexus ; and in the female, into the inferior vesical plexus.

The **prostaticovesical plexus** surrounds the prostate and neck of the bladder and lies between the sheath and fibrous capsule of the prostate. In front it is continuous with the pudendal plexus and behind with the superior vesical plexus.

The **inferior vesical plexus** of the female surrounds the neck of the bladder only and corresponds to the prostaticovesical plexus of the male.

The **haemorrhoidal plexus** surrounds the rectum. It consists of two portions : an internal and an external. The *internal plexus* lies between the muscular and mucous coats of the rectum arranged circularly above the anal orifice and is drained into the superior hæmorrhoidal vein. The *external plexus* lies upon the outer surface of the muscular coat of the rectum, its upper part is drained by the *superior haemorrhoidal vein* which constitutes the beginning of the inferior mesenteric vein, a main tributary of the portal vein ; its middle part is drained by the *middle haemorrhoidal vein* which opens into the hypogastric vein ; its lower part is drained by the *inferior haemorrhoidal veins* which open into the internal pudendal veins. It is through the hæmorrhoidal plexus that a free communication is established between the systemic and portal systems of veins.

The **uterine plexuses** lie along the sides of the uterus between the two layers of the broad ligament and communicate above with the ovarian plexus and below with the vaginal plexus. Two uterine veins, on each side, issue from the plexuses and terminate in the correponding hypogastric vein.

The **vaginal plexuses** lie at the sides of the vagina. They communicate above with the uterine plexuses, in front with the vesical plexus, and behind with the hæmorrhoidal plexus. Two vaginal veins, one on each side, issue from the plexuses and terminate in the hypogastric vein.

The **pudendal plexus** lies behind the arcuate ligament of the pubis from which the venæ comites of the internal pudendal artery begin. Its main tributary is the deep dorsal vein of the penis.

The **dorsal veins of the penis** are two, a superficial and a deep. The *superficial dorsal vein* drains the skin of the penis including the prepuce ; it runs backwards in the superficial fascia along the median line and ends in the corresponding superficial external pudendal vein. The *deep dorsal vein* is formed by minute veins from the glans and corpora cavernosa penis ; it passes backwards in the groove along the middle line of the dorsum of the penis and then between the two layers of the suspensory ligament ; it enters the pelvis below the pubic arcuate ligament and ends in the pudendal plexus. It sends a communicating twig to the internal pudendal vein. The dorsal vein of the clitoris has a similar course to that of the deep dorsal vein of the penis.

The **lateral sacral veins** accompany the lateral sacral arteries and terminate in the corresponding hypogastric vein.

## The Portal System of Veins

The portal system of veins includes all the veins which carry the blood from the abdominal portion of the alimentary canal, except the anal canal and from the spleen, pancreas and gall bladder. From all these viscera the blood is carried to the liver by the portal vein. The portal vein behaves like an artery and in the liver ends by breaking up into branches which ultimately end in capillary like vessels called *sinusoids*. The terminal branches of the hepatic artery also end into these sinusoids of the liver. From these sinusoids the hepatic veins arise and as the hepatic veins open into the inferior vena cava, the blood of the portal vein ultimately passes into the systemic circulation. The portal vein and its tributaries have no valves.

The **portal vein** (Figs. 184, 235) is a thick trunk about 3 inches in length, and is formed by the junction of the superior mesenteric and lienal veins, behind the neck of the pancreas and in front of the inferior vena cava at the level of the body of the second lumbar vertebra. It ascends behind the superior part of the duodenum and then between the two layers of the lesser omentum forming the anterior boundary of the epiploic foramen. In the lesser omentum it lies behind the bile duct and hepatic artery, the artery being on the left of the duct ; it is accompanied by numerous lymph vessels and is surrounded by the hepatic plexus of nerves. It next reaches the right extremity of the porta hepatis and presents a slight enargement, the *portal sinus*, and then divides into two branches, a right and a left. The *right branch* receives the cystic vein and ramifies in the right lobe of the liver. The *left branch*, longer than the right, runs from right to left along the porta hepatis and gives off branches to the caudate and quadrate lobes ; it crosses the fossa of the umbilical vein and ramifies in the substance of the left lobe of the liver. As it crosses the fossa of the umbilical vein it is joined in front by the para-umbilical veins and ligamentum teres and behind by the ligamentum venosum. The tributaries of the portal vein are : (1) coronary, (2) right gastric, (3) cystic, (4) para-umbilical, (5) superior mesenteric, and (6) lienal.

The **coronary vein** is formed by the union of tributaries from both surfaces of the stomach. It runs between the two layers of the lesser omentum from right to left along the lesser curvature of the stomach to the œsophagus where it receives some œsophageal tributaries. It next runs from left to right behind the omental bursa and opens into the portal vein.

The **right gastric vein** runs from left to right along the right portion of the lesser curvature between the two layers of the lesser omentum and opens into the portal vein.

The **cystic vein** returns the blood from the gall bladder ; it ascends along the cystic duct and opens into the right branch of the portal vein.

The **para-umbilical veins** are small veins which begin at the umbilicus run along the ligamentum teres of the liver and terminate in the left branch of the portal vein. At the umbilicus they establish communication with the veins of the anterior abdominal wall.

The **superior mesenteric vein** is formed by tributaries which return the blood from those parts of the intestinal canal supplied by the superior mesenteric artery. It receives in addition the right gastroepiploic and the pancreaticoduodenal veins which accompany their corresponding arteries. It ascends between the two layers of the mesentery on the right side of the superior mesenteric artery. As it ascends it passes in front of the right ureter, the lower part of the inferior vena cava, the horizontal part of the duodenum, and the uncinate process of the head of the pancreas. Finally it terminates behind the neck of the pancreas by joining the splenic vein to form the portal vein.

The **lienal vein** (splenic vein) is formed by the union of five or six branches which issue from the hilum of the spleen. It does not take a tortuous course like the artery but runs from left to right behind the upper border of the pancreas and below the lienal artery. It terminates behind the neck of the pancreas by joining at nearly a right angle with the superior mesenteric vein to form the portal vein. Its *tributaries* are the short gastric, left gastroepiploic, pancreatic, and inferior mesenteric. The *short gastric veins* return the blood from the fundus and left portion of the greater curvature of the stomach and open into the trunk of the splenic vein or one of its chief tributaries. The *left gastroepiploic vein* accompanies its corresponding artery and ends in the commencement of the splenic vein. The *pancreatic veins* issue from the substance of the pancreas.

The **inferior mesenteric vein** receives blood from those parts of the intestinal canal supplied by the inferior meseneric artery. It begins in the rectum as the *superior haemorrhoidal vein* (p. 459). It runs upwards on the left of the aorta and in front of the left psoas major ; it then passes behind the body of the pancreas and ends in the lienal vein. In addition to the superior hæmorrhoidal vein of which it is the direct continuation it receives the *sigmoid* and *left colic veins* which accompany the arteries of the same names.

The **communications between portal and systemic veins** are important in certain diseases for the establishment of a good collateral circulation. These communications are : (1) between the gastric veins and œsophageal veins which open into the hemiazygos vein ; (2) between the veins of the duodenum and colon and left renal vein which opens into the inferior vena cava ; (3) between the superior hæmorrhoidal vein (which constitutes the beginning of the inferior mesenteric vein) and the middle hæmorrhoidal vein which opens into the hypogastric vein, and the inferior hæmorrhoidal veins which open into the internal pudendal veins ; (4) between the left branch of the portal vein and the veins of the anterior abdominal wall through the para-umbilical veins ; (5) between the portal vein and the inferior vena cava if the ductus venosus remains patent ; (6) between the portal vessels over the intestines and posterior surface of the liver and the phrenic and azygos veins through the retroperitoneal plexus of veins.

## THE VEINS OF THE SUPERIOR EXTREMITY

The veins of the superior extremity consist of two sets—a superficial and a deep. The superficial veins ramify in the superficial fascia and do not accompany the arteries. The deep veins accompany the arteries. The superficial and deep veins communicate frequently with one another. Both sets of veins are provided with valves.

### The Superficial Veins of the Superior Extremity (Fig. 247)

The superficial veins of the superior extremity commence in the superficial fascia of the palm, of the dorsum of the hand, and of the digits.

**Superficial veins of the palm.**—The *proper volar digital veins* pass along the volar aspects of the digits in the superficial fascia. They open proximally into the superficial venous plexus overlying the thenar and hypothenar eminences. Opposite the clefts between the fingers the proper volar digital veins communicate with the dorsal veins by means of oblique *intercapitular veins.* The superficial venous plexus in the palm drains into the median antibrachial vein.

**Superficial veins of the dorsum of the hand.**—Two *dorsal digital veins,* one along the radial and one along the ulnar border, pass over the dorsum of each digit. The dorsal digital veins of the thumb terminate in the cephalic vein. The dorsal digital vein on the ulnar side of the little finger ends in the basilic vein. The remaining dorsal digital veins unite and form, opposite the heads of the metacarpal bones, three *dorsal metacarpal veins.* These three veins join with each other and form opposite the middle of the metacarpus, the *dorsal venous arch.* From the radial end of this venous arch the *cephalic vein* commences and from the ulnar side of it the *basilic vein* begins.

The **cephalic vein** begins from the lateral end of the dorsal venous network of the hand. It ascends along the dorsal aspect of the radial side of the forearm and gradually reaches its front aspect by winding round its radial margin. It then ascends along the front aspect of the radial side of the forearm receiving tributaries in its course and at the bend of the elbow it communicates with the basilic vein by a venous channel called the *median cubital vein.* Above the level of the median cubital vein the cephalic vein crosses the lateral antibrachial cutaneous nerve and passes upwards close to the lateral border of the biceps brachii ; at the upper part of the arm it ascends between the deltoideus and the pectoralis major ; here it is accompanied by the deltoid branch of the thoracoacromial artery. It then pierces the coracoclacivular fascia and terminates in the axillary vein. One of its tributaries is larger than the others and is called the *accessory cephalic vein ;* it runs along the dorsal aspect of the radial border of the forearm and joins the cephalic vein a little below the bend of the elbow.

The **basilic vein** begins at the medial end of the dorsal venous network of the hand. From its commencement it passes upwards at first along the dorsal aspect of the ulnar side of the forearm. Below the elbow it passes to the front aspect of the ulnar side of the forearm. At the bend of the elbow it is joined by the median cubital vein and as it ascends between the biceps brachii and pronator teres, twigs of the medial antibrachial cutaneous nerve come to lie in front and behind it. In the arm it ascends along the medial border of the biceps brachii, and pierces the deep fascia at about its middle. Finally it runs along the medial side of the brachial artery and, reaching the lower border of the teres major, becomes the axillary vein.

The **median cubital vein** (median basilic vein) arises from the cephalic vein at the bend of the elbow and passes upwards and medialwards to join the basilic vein. It lies on the lacertus fibrosus, which separates it from the brachial artery. It receives the profunda vein by which it is connected to the deep veins of the foramen.

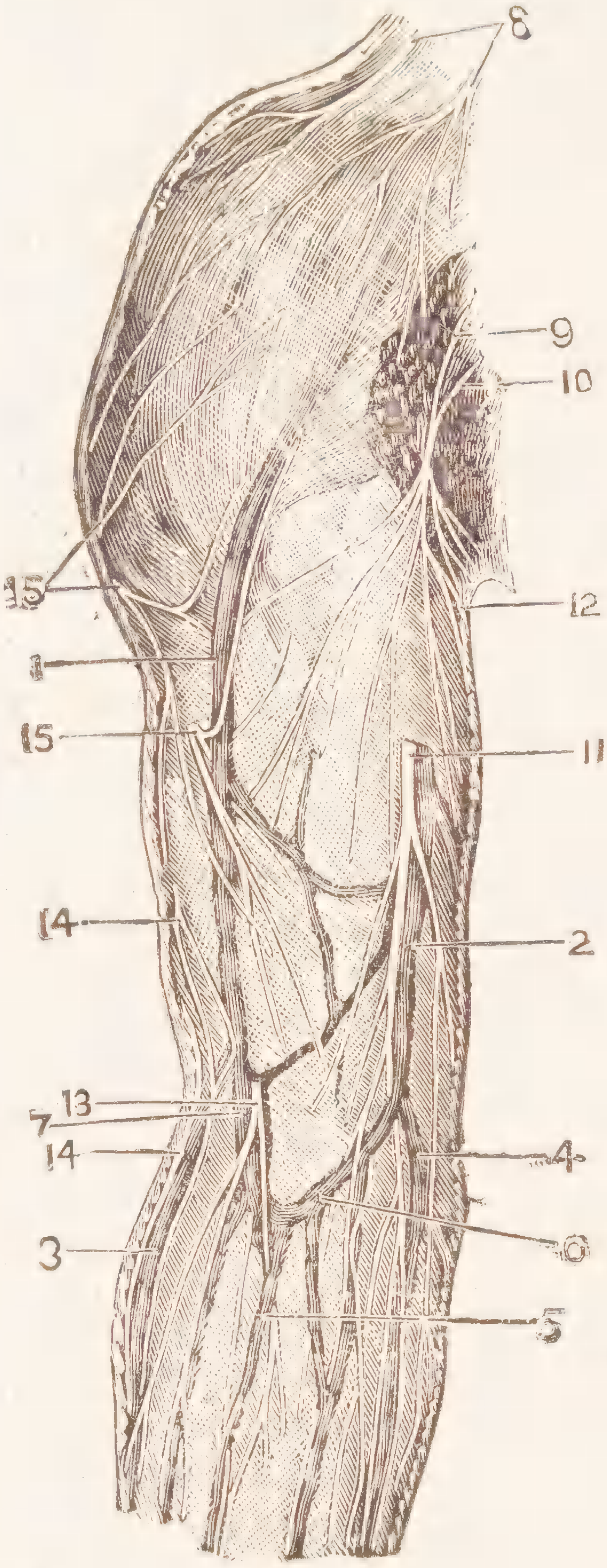

Fig. 247.—Cutaneous dissection of the front of the arm.

1. Cephalic vein.
2. Basilic vein.
3. Cephalic vein.
4. Basilic vein.
5. Median antibrachial vein dividing into 6, 7, median basilic and median cephalic veins.
8. Posterior supraclavicular branches.
9. Medial brachial cutaneous nerve.
10. Intercostobrachial nerve.
11. Medial antibrachial cutaneous nerve.
12. Posterior brachial cutaneous branch of radial nerve.
13. Musculocutaneous nerve.
14. Dorsal antibrachial cutaneous branch of the radial nerve.
15. Axillary nerve.

The **median antibrachial vein** begins in a venous plexus on the volar aspect of the hand and ascends along the middle line of the front of the forearm to join the median cubital vein or the basilic vein at the bend of the elbow. When the median cubital vein is absent, the median antibrachial vein usually bifurcates at the bend of the elbow into two branches, median basilic and median cephalic. The *median basilic vein* passes upwards and medialwards to join the basilic vein; and the *median cephalic vein* passes upwards and lateralwards to join the cephalic vein. Before its bifurcation it communicates with the venæ comites of the brachial artery.

### The Deep Veins of the Superior Extremity

The deep veins of the superior extremity, with the exception of the axillary vein, are arranged in pairs which form venæ comites and accompany the corresponding arteries. These veins are situated one on each side of the artery and are provided with valves ; they are connected at intervals by transverse branches. Beginning at the fingers, the proper volar digital veins unite to form the common volar digital veins which open into the superficial volar venous arch. Similarly the volar metacarpal veins corresponding to the branches of the deep volar arch open into the deep volar venous arch. The venæ comites of the radial artery is the upward continuation of the deep volar venous arch and those of the ulnar artery of the superficial volar venous arch. The radial and ulnar venæ comites unite at the bend of the elbow to form the brachial venæ comites. The ulnar venæ comites send a communicating branch, the *profunda vein*, to the median cubital vein. The venæ comites of the brachial artery join the axillary vein at the lower border of the subscapularis.

The **axillary vein** is the direct continuation of the basilic vein. It begins at the lower border of the teres major and becomes the subclavian vein at the outer margin of the first rib. It receives tributaries corresponding to the branches of the axillary artery ; at the lower border of the subscapularis it is joined by the venæ comites of the brachial artery ; near its termination the cephalic vein opens into it. *Relations.*—Its *anterior* relations are similar to those of the axillary artery ; its *posterior* relations are the first digitation of the serratus anterior and the muscles forming the posterior wall of the axilla. *Lateral* to it is the axillary artery ; it is separated from the first part of the artery by the medial anterior thoracic nerve ; from the second part of the artery by the medial cord of the brachial plexus ; from the third part of the artery by the ulnar nerve and medial antibrachial cutaneous nerve. *Medial* to it is the medial brachial cutaneous nerve.

## THE VEINS OF THE INFERIOR EXTREMITY

The veins of the inferior extremity ,like those of the superior extremity, consist of two sets—a superficial and a deep. The superficial veins ramify in the superficial fascia and do not accompany arteries ; they terminate in the deep veins. The deep veins with the exception of the popliteal and femoral veins accompany the arteries, one on each side, and form venæ comites. Both sets of veins are provided with valves which are more numerous in the veins of the inferior extremity than in those of the superior extremity.

### The Superficial Veins of the Inferior Extremity

**On the sole of the foot** the superficial veins form an arch which extends across the roots of the toes ; this arch is called the *plantar cutaneous venous arch.* Proximal to this arch is another network on the sole and is called the *plantar cutaneous venous network* which communicates with the plantar cutaneous venous arch and with the deep veins of the foot. **On the dorsum of the foot** the superficial veins are the dorsal digital veins, the dorsal metatarsal veins, the dorsal venous arch, and the commencement of the great and small saphenous veins. Two *dorsal digital veins* run along the dorsum of each toe, one along the medial side and the other on the lateral side. On reaching the clefts between the toes they receive *intercapitular veins* from the plantar digital veins. The two dorsal digital veins which run along the two contiguous sides of adjacent toes unite at the clefts between them to form a trunk ; in this way four trunks, called the *dorsal metatarsal veins*, are formed which terminate in the dorsal venous arch. The medial dorsal digital vein (medial marginal vein) of the great toe joins with the medial end of the dorsal venous arch while the lateral dorsal digital vein of the little toe (lateral marginal vein) unites with the lateral end of the arch. The *dorsal venous arch* extends across the distal end of the metatarsal bones. This venous arch receives along its convexity the four dorsal metatarsal veins. A network of veins is situated in the concavity of the arch and communicates with the arch.

The **great saphenous vein** (Fig. 239) is formed by the union of the medial end of the dorsal venous arch with the medial dorsal digital vein of the great toe. It ascends in front of the medial malleolus and along the medial surface of the distal third of the tibia and then behind the medial margin of the tibia to the knee where it lies behind the medial condyle of the femur. It then proceeds upwards along the anteromedial aspect of the thigh. Reaching the fossa ovalis it pierces the fascia cribrosa and the femoral sheath and terminates in the femoral vein. In the foot and leg it is accompanied by the saphenous nerve which lies in front of the vein ; at the knee, by the saphenous branch of the highest genicular artery ; in the thigh, by branches of the medial femoral cutaneous nerve. It contains from eight to twenty valves. *Tributaries.*—In the foot it receives tributaries from the medial part of the sole of the foot ; in the leg it receives several cutaneous veins and communicates with the small saphenous vein ; in the thigh it receives several tributaries and amongst them are two veins one placed on the medial aspect and the other on the posterior aspect—these two veins join to form the *accessory saphenous vein* which opens into the great saphenous vein. Its last tributaries are the superficial epigastric, superficial iliac circumflex, and superficial external pudendal veins which open into it near the fossa ovalis.

The **small saphenous vein** (Fig. 237) is formed by the union of the lateral end of the dorsal venous arch with the lateral dorsal digital vein of the little toe. It ascends behind the lateral malleolus and along the lateral margin of the tendo calcaneus in company with the sural nerve. It next crosses the tendon and reaches the middle line of the back of the leg. Thereafter it ascends along the middle line of the back of the leg between the two heads of the gastrocnemius and pierces the deep fascia over the lower part of the popliteal fossa to terminate in the popliteal vein. In the lower part of its ascent along the middle line of the back of the leg it is accompanied by the medial sural cutaneous nerve; and in the upper part, by the posterior femoral cutaneous nerve. It contains from about eight to twelve valves. *Tributaries.*—In the foot it receives tributaries from the lateral part of the sole of the foot; from the back of the leg it receives several tributaries; its communicating branch with the great saphenous vein may be sufficiently large so as to form the direct continuation of the small saphenous vein which in such a case has no connection at all with the popliteal vein.

## The Deep Veins of the Inferior Extremity

The deep veins of the inferior extremity accompany their corresponding arteries; there are two veins to each artery and thus form venæ comites with the exception of the popliteal and femoral veins. Beginning at the toes, the plantar digital veins unite to form four plantar metatarsal veins which again unite to form the *deep plantar venous arch* which lies by the side of the plantar arterial arch. From this arch the *medial* and *lateral plantar veins* accompany the corresponding arteries and unite to form the posterior tibial veins. On the dorsum of the foot the venæ comites of the dorsalis pedis artery run upwards to form the anterior tibial veins which unite with the posterior tibial veins at the back of the leg to form the popliteal vein. On the back of the leg the posterior tibial veins accompany the posterior tibial artery and receive tributaries corresponding to the branches of the artery including the peroneal veins.

The **popliteal vein** (Fig. 237) is formed at the lower border of the popliteus by the union of the anterior and posterior tibial veins. It runs through the popliteal fossa and enters the adductor canal through the opening in the adductor magnus where it becomes the femoral vein. At its commencement it lies to the medial side of the artery and to the lateral side of the tibial nerve; it then inclines to the lateral side of the artery; next it lies posterior to the artery—the tibial nerve occupies the most posterior position of the three; finally near its end it lies to the lateral side of the artery—the tibial nerve still occupies the posterior position. The popliteal vein is provided with two or three valves and is firmly connected with the artery by dense fibrous tissue. It receives tributaries corresponding to the branches of the popliteal artery and also the small saphenous vein.

The **femoral vein** (Fig. 238) begins at the opening in the adductor magnus as the direct continuation of the popliteal vein, and ends behind the inguinal ligament to become the external iliac vein. It lies medial to the femoral artery in the upper part of the femoral triangle where it occupies the intermediate compartment of the femoral sheath; in the lower part of the femoral triangle and in the upper part of the adductor canal it lies behind the artery ; in the lower part of the adductor canal it lies lateral to the artery. It receives the great saphenous vein, profunda femoris vein, and muscular tributaries.

## Peculiarities of the Vascular System of the Fœtus

The structures peculiar to the vascular system of the fœtus are : (1) foramen ovale, (2) the valve of the inferior vena cava, (3) the ductus arteriosus, (4) hypogastric and umbilical arteries, (5) umbilical vein, and (6) ductus venosus.

The *foramen ovale* is an oval aperture in the atrial septum through which blood passes from the right to the left atrium in the fœtus. It is closed shortly after birth.

The *valve of the inferior vena cava* is of large size in the fœtus and directs the blood from the inferior vena cava into the left atrium through the foramen ovale.

The *ductus arteriosus* conveys the blood from the pulmonary artery to the aorta in the fœtus. It is a short tube which connects the trunk of the pulmonary artery to the arch of the aorta, just beyond the origin of the left subclavian artery. It is closed shortly after birth.

The *hypogastric arteries*, right and left, are of large size in the fœtus ; they run along the sides of the urinary bladder and then upwards on the back aspect of the anterior abdominal wall to the umbilicus. The two hypogastric arteries now pass through the umbilicus to the placenta along the umbilical cord assuming the name of *umbilical arteries* which carry impure blood from the fœtus to the placenta. After birth the pelvic portion of the hypogastric artery remains patent and forms the hypogastric artery and the proximal portion of the superior vesical artery. The remainder of the vessel up to the umbilicus is converted into a fibrous cord, called the *lateral umbilical ligament.*

The *umbilical vein* caries pure blood from the placenta to the fœtus. Beginning at the placenta it proceeds to pass through the umbilicus and then along the free margin of the falciform ligament of the liver to the fossa of the umbilical vein on the inferior surface of the liver ; here it joins the left branch of the portal vein. It then continues its course assuming the name of the *ductus venosus* to end in that portion of the inferior vena cava which is situated in the fossa for the inferior vena cava of the liver. After birth the umbilical vein and ductus venosus become obliterated ; the former is now called the *ligamentum teres,* and the latter, *ligamentum venosum,* of the liver.

## The Fœtal Circulation (Fig. 248)

The umbilical vein carries the purified blood for the nutrition of the fœtus from the placenta and enters the abdomen at the umbilicus whence it passes along the free margin of the falciform ligament of the liver to the inferior surface of that organ where it gives off two branches to the liver. Reaching the porta hepatis

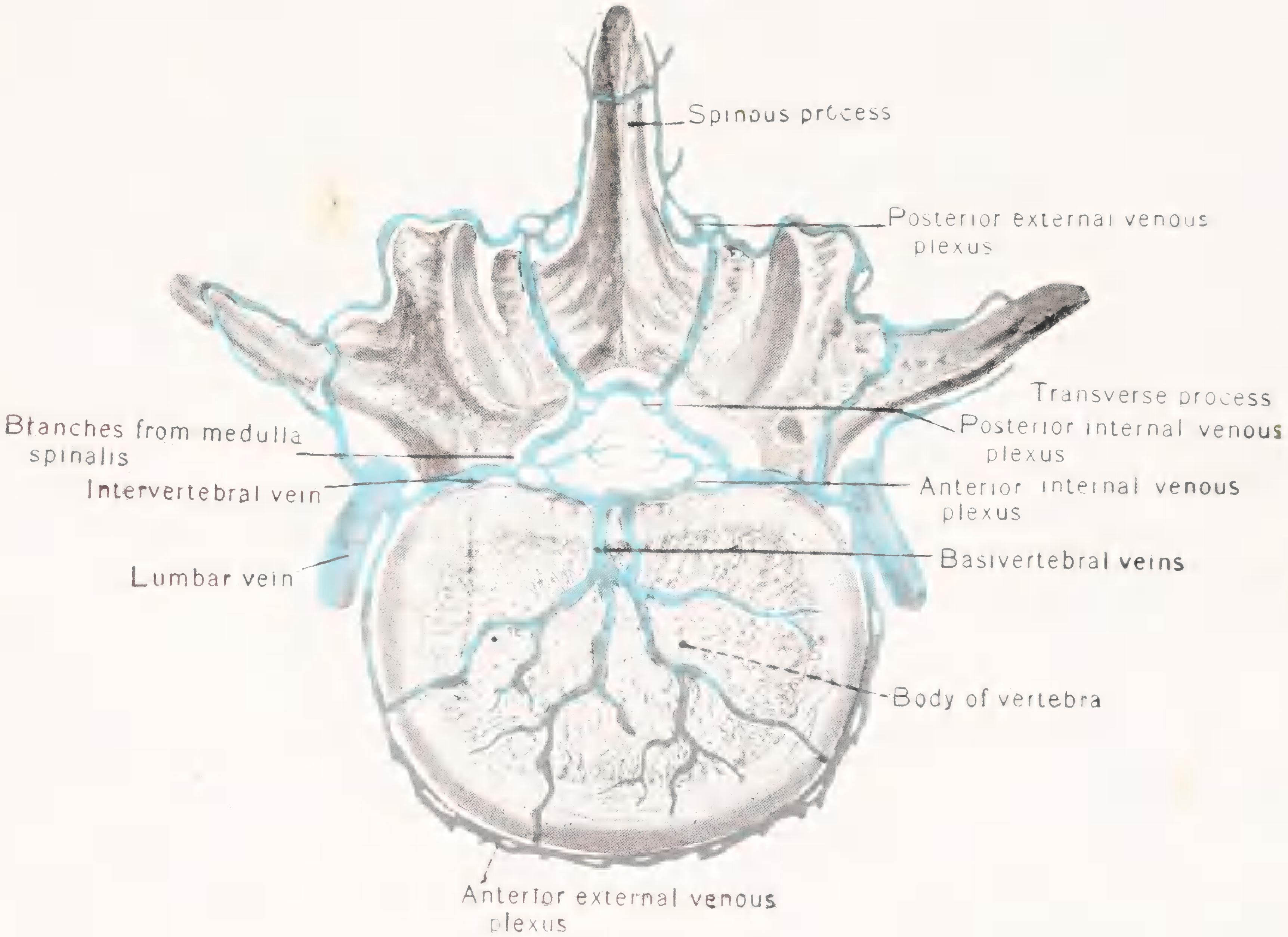
Spinous process
Posterior external venous plexus
Transverse process
Posterior internal venous plexus
Branches from medulla spinalis
Intervertebral vein
Anterior internal venous plexus
Basivertebral veins
Lumbar vein
Body of vertebra
Anterior external venous plexus

Fig. 246.—Diagram to illustrate the vertebral venous plexuses.

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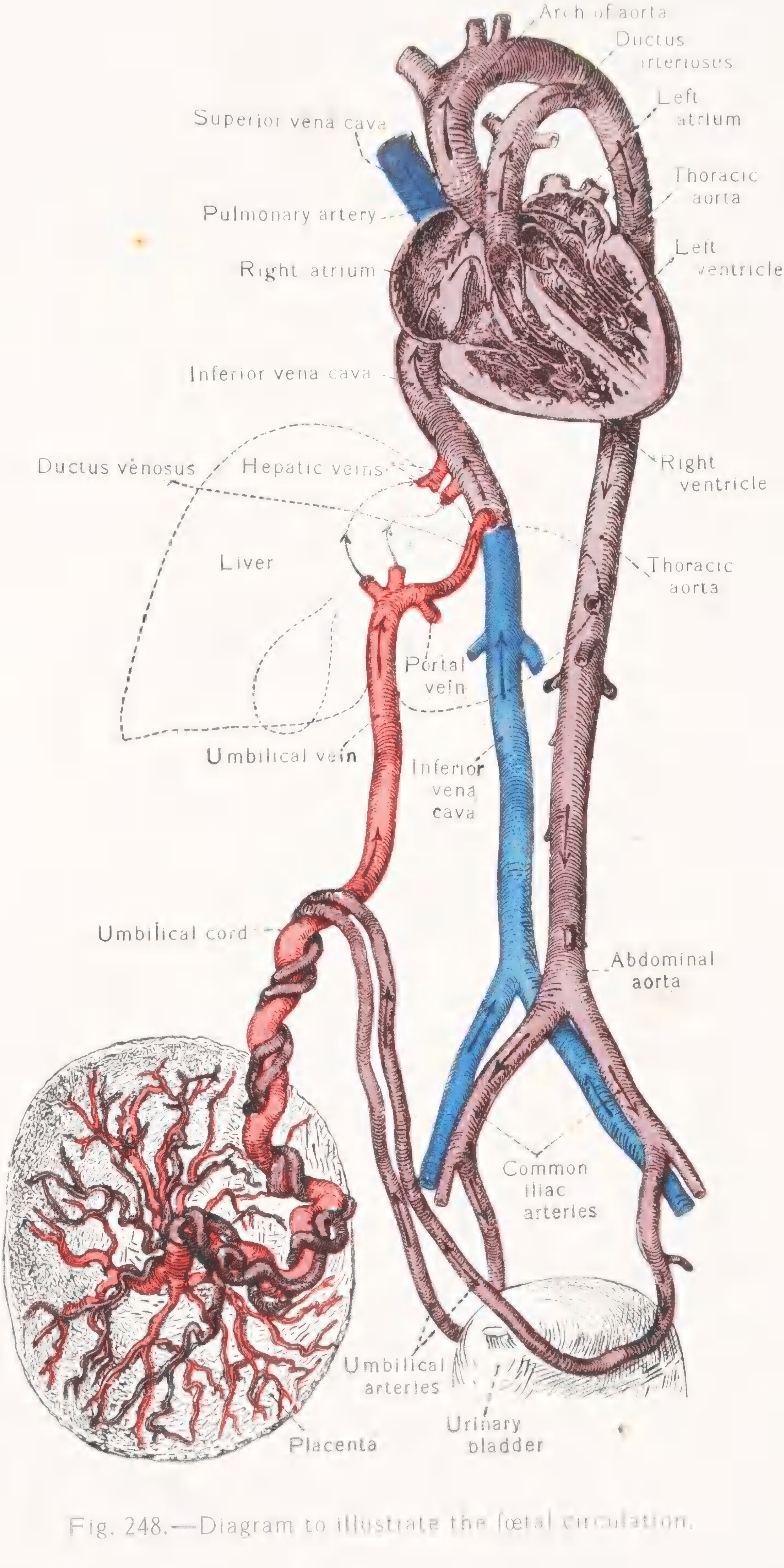

Fig. 248.—Diagram to illustrate the fœtal circulation.

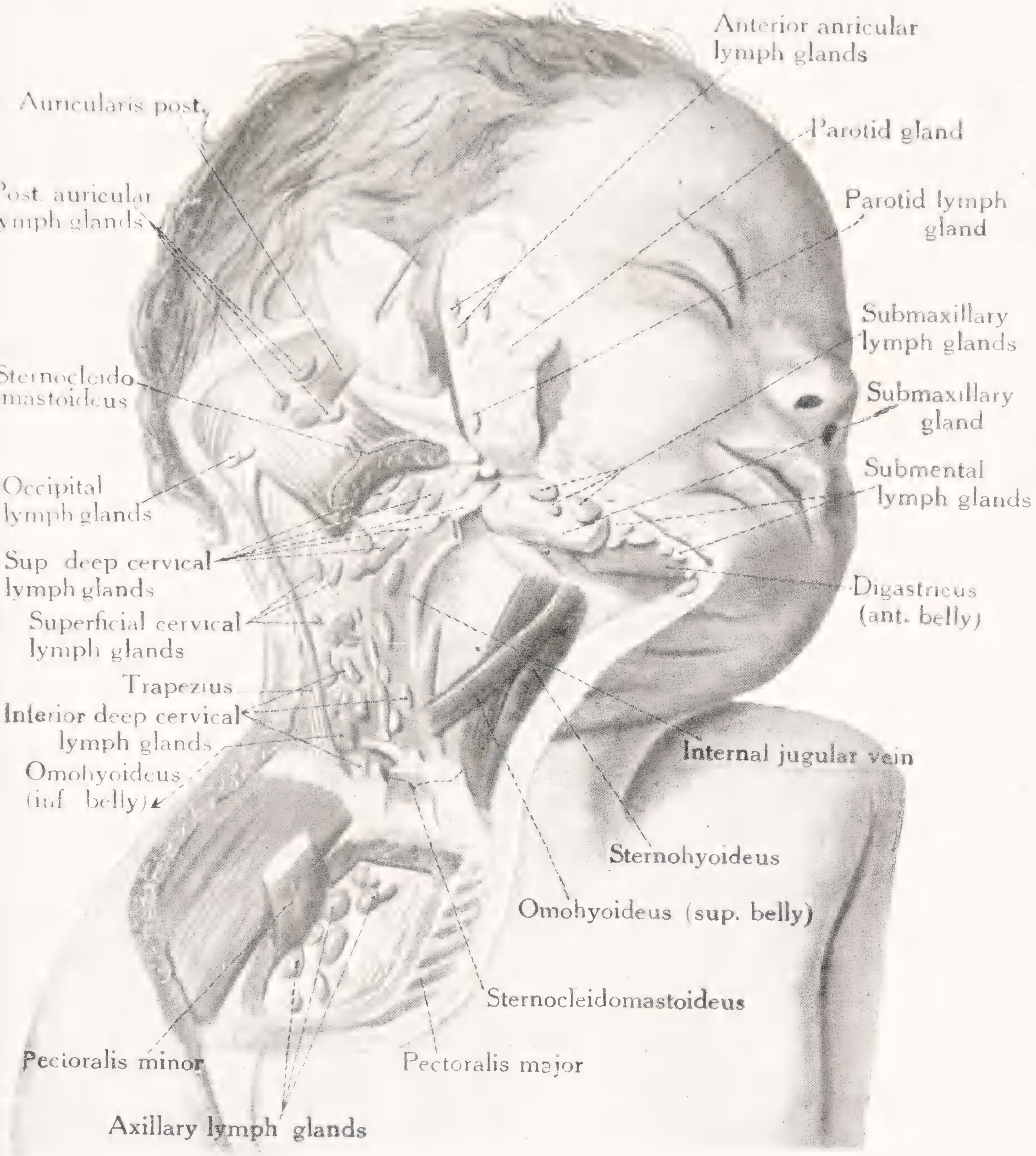

Fig. 249.—The lymple glands of the head, neck and axilla.

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it divides into two branches : of these, the smaller branch, called the ductus venosus, enters the inferior vena cava ; the larger branch joins the portal vein and conveys its blood eventually to the infeior vena cava through the hepatic veins. Thus the inferior vena cava receives the placental blood carried by the ductus venosus and the hepatic veins ; further this blood is mingled with the venous blood conveyed to the inferior vena cava from the inferior extremities and abdominal wall. This blood is therefore of a mixed nature, being partly pure placental blood and partly venous, and enters the right atrium. The valve of the inferior vena cava which is of large size in the fœtus, directs the current across the atrium to the patent foramen ovale and the blood enters the left atrium where it becomes mingled with a little quantity of venous blood returned from the undistended lungs by the pulmonary veins. From the left atrium the blood passes into the left ventricle and is thence propelled through the aorta to the head and neck and superior extremities, a small quantity only passing into the descending aorta. From the head and neck and superior extremities the blood is carried through the superior vena cava into the right atrium where it becomes mixed with a small quantity of blood derived from the inferior vena cava. From the right atrium it passes at once into the right ventricle, thus taking a course at right angles to the inferior caval stream. Fom the right ventricle the blood is propelled into the pulmonary artery ; only a small portion is distributed to the lungs through the right and left pulmonary arteries (the lungs being almost solid organs in the fœtus) and is returned by the pulmonary veins into the left atrium as already referred to ; by far the larger portion of blood is diverted through the ductus arteriosus into the aorta, in which situation it becomes mixed with the small quantity of blood which comes from the left ventricle into the aorta distal to the origin of the left subclavian artery. Through the aorta the blood descends and this blood is chiefly impure on account of its admixture with the venous blood conveyed by the ductus arteriosus ; this blood has a twofold destination : a small portion of it is distributed to the abdominal and pelvic viscera and the inferior extremities whence it is carried back by the portal vein and inferior vena cava ; the chief portion, however, is transmitted through the comparatively large hypogastric arteries of the fœtus which, after passing through the umbilicus, are carried with the umbilical cord as umbilical arteries, and is thus conveyed to the placenta for purification.

From the above description of the circulation of blood in the fœtus the following conclusions can be drawn: (1) the placental stream is conveyed by the umbilical vein and contains pure blood ; (2) the superior caval stream goes in part to supply the lungs, abdomen and inferior extremities, contains relatively impure blood and contaminates the placental stream partially in the right atrium ; (3) the inferior caval stream is partly pure and partly impure ; (4) there is a double stream at the right atrium—

the superior caval stream flows into the right ventricle while the inferior caval stream passes directly into the left atrium; (5) the head and neck and superior extremities are supplied with comparatively purer blood while the abdomen (except the liver which is supplied with pure blood coming directly from the placenta) and the inferior extremities are supplied with mostly impure blood.

### Changes at Birth

At birth the lungs assume their function and the placental circulation is arrested. The structures peculiar to the vascular system of the fœtus are closed completely between the eighth and tenth days after birth. The right and left pulmonary arteries rapidly enlarge. The foramen ovale is closed by the septum secundum about the tenth day after birth and thus the blood entering the right atrium finds only one exit viz., the right atrioventricular orifice. The ductus arteriosus becomes closed about the fifth day after birth and thus the blood traversing the aortic arch passes readily into the descending aorta; it remains as a fibrous cord, the *ligamentum arteriosum,* which connects the root of the left pulmonary artery to the arch of the aorta immediately beyond the origin of the left subclavian artery. The umbilical vein becomes obliterated between the second and fifth days after birth and forms the *ligamentum teres* of the liver. The ductus venosus becomes obliterated between the second and fifth days after birth and forms the *ligamentum venosum.* The portions of the hypogastric arteries which extend from the sides of he bladder to the umbilicus become obliterated between the second and fifth days after birth and form fibrous cords called the *lateral umbilical ligaments.*

## THE LYMPHATIC SYSTEM

The lymphatic system comprises the lymphatic vessels and lymph glands.

The **lymphatic vessels** contain a colourless fluid called *lymph* but the lymphatic vessels of the small intestine contain a milky white fluid, called *chyle,* and are termed *lacteals* or *chyliferous vessels.* They accompany the blood vessels and are more numerous than the latter. They unite together like the veins to form larger and larger lymph vessels and ultimately all the lymph passes into two main trunks, the thoracic duct and the right lymphatic duct, which terminate in large veins at the root of the neck. They are present in all tissues except cartilage and are divided into superficial and deep; the former lie in the subcutaneous tissues and the latter beneath the deep fascia. They are also divided into afferent and efferent vessels from the fact that all lymph passes through at least one lymph gland before it is poured into the terminal vessels. The *afferent* lymphatic vessels carry lymph to the lymph glands while the *efferent* vessels convey the lymph from the glands. Like veins the lymphatic vessels are provided with valves which are more numerous; each vessel has three coats—an external, a middle, and an internal. The *external coat* consists of connective tissue intermingled with unstriped muscular fibres ; the *middle coat* consists of unstriped muscular fibres intermingled with elastic fibres ; the *internal coat* consists of an endothelial layer covered externally by elastic fibres.

The **lymph glands** are oval or flattened bodies which are situated in the course of lymphatic vessels and serve as filters to the lymph brought to them. Each gland presents a depression, called the *hilum*, which gives passage to the blood vessels, nerves, and the efferent vessels. The afferent vessels enter lymph glands at some part of their periphery. Each lymph gland consists of the following parts : (1) a capsule from which trabeculæ pass inside the gland and divide it into communicating spaces ; (2) minute blood vessels ; (3) afferent and efferent lymph vessels ; (4) a certain amount of lymphoid tissue. In certain parts of the body, e.g. along the abdominal aorta, structures like lymph glands, are seen which contain blood in some of their spaces —these are known as *haemal lymph glands.*

### The Thoracic Duct (Figs. 232, 245)

The **thoracic duct** conveys the whole of the lymph from the inferior extremities, the abdomen (except the lymph from the upper surface of the liver), the left half of the thoracic wall, the left lung and the left half of the heart, the left superior extremity, and the left side of the head and neck. It begins in the abdomen in a dilatation, the *cisterna chyli,* ascends through the posterior mediastinum and superior medistinum to the root of the neck, and terminates by opening into the angle of junction of the internal jugular and subclavian veins of the left side.

**In the abdomen.**—From the cisterna, the thoracic duct runs upwards, and enters the thorax through the aortic opening of the diaphragm where it lies between the aorta on the left, and the azygos vein and the right crus of the diaphragm on the right.

**In the posterior mediastinum.**—After entering the thorax, it ascends through the posterior mediastinum behind the œsophagus and in front of the vertebral column and crosses the right aortic intercostal arteries and the terminal parts of the hemiazygos and accessory hemiazygos veins. Up to the level of the fifth thoracic vertebra it occupies the middle line ; at this level it turns abruptly to the left of the middle line behind the arch of the aorta and ascends through the superior mediastinum.

**In the superior mediastinum.**—It lies behind the œsophagus, the aortic arch, the left subclavian artery and the pleura. As it enters the root of the neck it lies behind the left common carotid artery and is covered by the œsophagus and left pleura.

**At the root of the neck.**—Reaching the seventh cervical vertebra it forms an arch by turning lateralwards, forwards and downwards in contact with the apex of the left pleural sac ; finally it turns medialwards and terminates at the angle of junction of the left internal jugular vein and left subclavian vein. At the root of the neck it lies anterior to the vertebral artery the thyreocervical trunk or its branches, the medial border of the scalenus anterior and the left phrenic nerve; and it lies posterior to the left carotid sheath and its contents.

The thoracic duct is about 18 inches long. At its origin it is dilated and is about the diameter of a goose quill; in the lower part of the thorax it is of a smaller calibre; at its termination it slightly dilates again; sometimes these dilatations are absent. Not infrequently the duct consists of two branches or of a series of anastomosing branches. The thoracic duct is freely provided with valves which are arranged in pairs; when distended it presents a beaded or nodulated appearance on account of these valves. The most important pair of valves is at the termination where they are directed towards the vein and prevent the flow of blood into the duct.

The **cisterna chyli** is the dilated commencement of the thoracic duct and is situated in front of the bodies of the first and second lumbar vertebræ. It is somewhat elliptical in shape and is about 2 inches long and ¼ inch at its broadest part. Above it becomes narrow and is continued into the thoracic duct. It has the aorta on the left side and in front; the azygos vein and right crus of the diaphragm on the right side.

**Tributaries.**—The cisterna chyli receives the following efferent lymph vessels: (1) the *right* and *left common lumbar lymph trunks* which are formed by the efferent lymph vessels from the lateral aortic lymph glands lying at the sides of the inferior vena cava and aorta and join the lower end of the cisterna; they carry lymph from the inferior extremities, the abdominal and pelvic walls, the pelvic viscera, kidneys, and suprarenal glands. (2) The *intestinal lymph trunk* which is formed by the efferent lymph vessels from the preaortic lymph glands; it joins the cisterna at its middle and carries lymph from the lower and front part of the liver, stomach, small intestine, pancreas and spleen. (3) The two *descending lymph trunks* each of which is formed by the efferent vessels from the corresponding intercostal lymph glands of the lower six intercostal spaces; each passes through the aortic opening of the diaphragm and opens into the upper end of the cisterna or a little higher up into the thoracic duct. In the thorax the thoracic duct receives (1) a trunk which drains the lumbar lymph glands, (2) the efferents from the posterior mediastinal lymph glands, (3) the efferents from the posterior intercostal lymph glands of the upper six left spaces. In the neck, the thoracic duct receives (1) the left jugular trunk, (2) the left subclavian trunk, and (3) occasionally the left bronchomediastinal trunk.

The **right lymphatic duct** (Fig. 245) is a short trunk, ¾ inch long, which lies along the medial border of the right scalenus anterior at the root of the neck. It is formed by the union of the right bronchomediastinal trunk, the right jugular trunk and the right subclavian trunk. It ends at the junction of the right subclavian and right internal jugular veins. The *right bronchomediastinal trunk* receives lymph from the right half of the thoracic wall, right lung, right half of the heart, and upper surface of the liver. The *right jugular trunk* receives lymph from the right side of the head and neck. The *right subclavian trunk* receives lymph from the right superior extremity.

## The Lymph Glands of the Head (Fig. 249)

The **lymph glands of the head** are all extracranial and consist of the following sets: (1) occipital, (2) anterior auricular, (3) posterior auricular, (4) parotid, (5) superficial facial, (6) deep facial, and (7) lingual.

The **occipital lymph glands**, two or three in number, lie on the upper part of the trapezius or semispinalis capitis. They receive afferent vessels from the occipital region of the scalp; their efferents pass to the deep cervical glands.

The **anterior auricular lymph glands** (parotid lymph glands) lie on the lateral surface of the parotid gland on the superficial and deep aspects of the parotid fascia. They receive afferents from the frontal and temporal regions of the scalp and from the lateral surface of the auricula; their efferents pass to the superficial and upper deep cervical glands.

The **posterior auricular lymph glands** lie on the upper part of the sternocleidomastoideus. They receive afferents from the parietal region of the scalp and from the medial surface of the auricula; their efferents pass to the superficial and deep cervical glands.

The **parotid lymph glands** (deep parotid glands) lie embedded in the substance of the parotid gland. They receive afferents from the nose, cheek, soft palate, external acoustic meatus and tympanic cavity; their efferents pass to the upper deep cervical glands.

The **superficial facial lymph glands** consist of three groups: (1) the *infraorbital* which lie below the margin of the orbit—they receive afferents from the neighbouring region and their efferents pass to the anterior auricular and submaxillary lymph glands; (2) the *buccinator* which lie on the buccinator near the angle of the mouth—they receive afferents from the cheeks and eyelids and their efferents pass to the anterior auricular glands; (3) the *supramandibular* which lie on the outer surface of the mandible and in front of the masseter—they receive afferents from the lower lip and their efferents pass to the anterior auricular and superficial cervical glands.

The **deep facial lymph glands** lie on the outer surface of the pterygoideus externus in relation with the internal maxillary artery. They receive afferents from temporal fossa, infratemporal fossa and palate; their efferents pass to the upper deep cervical glands.

The **lingual lymph glands** lie between the genioglossi and on the lateral surface of the hyoglossus. They are placed in the course of lymphatic vessels which pass from the tongue to the deep cervical glands.

### The Lymph Glands of the Neck (Fig. 249)

The lymph glands of the neck consist of the following sets: (1) superficial cervical, (2) deep cervical, (3) anterior cervical, (4) submaxillary, (5) submental, and (6) retropharyngeal.

The **superficial cervical lymph glands** lie along the course of the external jugular vein. They receive afferents from the parotid region and auricula; their efferents pass to the superior deep cervical glands.

The **deep cervical lymph glands** consist of two groups: (1) the *superior deep cervical lymph glands* which lie in relation with the internal jugular vein—they receive lymph from the three salivary glands, mouth, tongue, pharynx, larynx, tonsil, thyreoid gland and upper part of the neck and their efferents pass to the inferior deep cervical glands; (2) the *inferior deep cervical glands* which lie in relation with the brachial plexus and subclavian vein—they receive lymph from the lower part of the neck, upper part of thorax and lateral part of arm and their efferents pass to the jugular lymphatic trunk.

The **anterior cervical lymph glands** consist of two sets, a superficial and a deep. The *superficial* set lies in relation with the anterior jugular vein. The *deep* set consists of: (1) the *infrahyoid lymph glands* which lie in front of the hyothyreoid membrane—they receive lymph from the region of the epiglottis and their efferents pass to the deep cervical glands; (2) the *prelaryngeal lymph glands* which lie on the cricothyreoid ligament—they receive lymph from the larynx and thyreoid gland and their efferents pass to the deep cervical glands; (3) the *pretracheal lymph glands* which lie along the inferior thyreoid veins—they receive lymph from the trachea and pass to the inferior deep cervical glands: (4) the *paratracheal lymph glands* which lie in relation with the recurrent nerves on the lateral aspect of the trachea—they receive lymph from the neighbouring region and their efferents pass to the deep cervical glands.

The **submaxillay lymph glands** lie on the superficial aspect of the submaxillary gland. They receive lymph from the lips, gums, tongue, and submaxillary and sublingual glands; their efferents pass to the superior deep cervical glands.

The **submental lymph glands** lie between the anterior bellies of the two digastric muscles. They receive lymph from the lower lip, floor of mouth and tip of tongue; their efferents pass to the submaxillary lymph glands and also to a deep cervical gland situated on the internal jugular vein.

The **retropharyngeal lymph glands** lie on the buccopharyngeal fascia. They receive lymph from the nasal cavity and nasal portion of pharynx ; their efferents pass to the superior deep cervical lymph glands.

### The Lymphatic Vessels of the Head and Neck

**Intracranial lymphatic vessels.**—The cerebrospinal fluid is secreted by the chorioid plexuses of the ventricles of the brain. The fluid passes from the fourth ventricle into the cerebellomedullary subarachnoid cistern. A portion of this fluid transudes through the arachnoideal granulations into the superior sagittal sinus ; a portion passes by osmosis into the subdural space ; from this space it passes into the lymphatics of the meninges and thence into the exterior of the cranium. Although this fluid is not true lymph, yet it cannot be denied that it is only a modified form of lymph and a portion of it actually passes into the lymphatic vessels.

**Lymphatic vessels of the head.**—The lymphatic vessels of the frontal and anterior temporal regions pass to the anterior auricular glands ; those of the posterior temporal and parietal regions pass to the posterior auricular glands ; those of the occipital region pass to the occipital glands.

**Lymphatic vessels of the neck.**—The lymphatic vessels of the skin and muscles of the neck pass to the deep cervical glands ; of the lymphatic vessels of the thyreoid gland, the upper pass to the superior cervical lymph glands and the lower end in the pretracheal lymph deep glands ; of the lymphatic vessels of the pharynx, the upper pass to the retropharyngeal lymph glands and the lower end in the deep cervical lymph glands ; of the lymphatic vessels of the larynx, the upper pass to the superior deep cervical lymph glands and the lower end in the pretracheal lymph glands.

**Lymphatic vessels of the face.**—The lymphatic vessels of the eyelids, conjunctiva and posterior part of cheek pass to the parotid lymph glands ; those from the anterior part of the cheek, upper lip, lateral part of the lower lip and side of the nose pass to the submaxillary lymph glands ; those from the central part of the lower lip pass to the submental lymph glands.

The **lymphatic vessels of the mouth.**—The lymphatic vessels of the gums pass to the submaxillary lymph glands ; those from the hard palate pass to the superior deep cervical glands ; those from the soft palate pass to the subparotid and superior deep cervical lymph glands ; those from the floor of the mouth pass to the submaxillary and superior deep cervical lymph glands.

The **lymphatic vessels of the tongue** may be divided into two groups : those from the tip and under surface of the anterior free portion of the tongue end in the submental glands ; those from the rest of the tongue end in the deep cervical lymph glands.

The **lymphatic vessels of the nasal cavities.**—The lymphatic vessels from the anterior one third of the nasal cavities pass to the submaxillary lymph glands ; those from the posterior two thirds end in the superior deep cervical lymph glands.

### The Lymph Glands of the Thorax

The lymph glands of the thorax consist of five groups.

(1) The **sternal** or **internal mammary lymph glands**, 8 to 12 in number, lie at either margin of the sternum along the course of the internal mammary artery. They receive afferents from the mamma, from the anterior part of the thoracic wall, from the upper part of the anterior abdominal wall, and from the upper surface of the liver; their efferents unite to form a single trunk on either side which opens into the junction of the internal jugular and subclavian veins.

(2) The **intercostal lymph glands** lie on the posterior thoracic wall in the posterior parts of the intercostal spaces and on the heads of the ribs. They receive lymph from the posterior parts of the intercostal spaces. The efferents from the lower four or five spaces unite to form a trunk which descends and opens into the cisterna chyli or a little higher up into the thoracic duct. The efferents from the upper spaces open into the thoracic duct on the left side and into the right lymphatic duct on the right side.

(3) The **diaphragmatic lymph glands** lie on the thoracic surface of the diaphragm and are divisible into three sets; anterior, middle, and posterior. The *anterior set* consists (*a*) of lymph glands situated at the union of the seventh rib with its cartilage and receives lymph from the front of the diaphragm, and (*b*) of lymph glands situated behind the xiphoid process which receives lymph from the superior surface of the liver—the efferents of this set end in the sternal lymph glands. The *middle set* lies at the sides where the phrenic nerves pass through the diaphragm. They receive afferents from the middle portion of the diaphragm; their efferents end in the posterior mediastinal lymph glands. They *posterior set* lies on the crura of the diaphragm and is connected with the posterior mediastinal and the lumbar lymph glands.

(4) The **mediastinal lymph glands** consist of two groups, anterior and posterior. The *anterior mediastinal lymph glands* lie in the anterior part of the superior mediastinum in front of the arch of the aorta and in relation with its three branches. They receive lymph from the pericardium, the heart and the thymus. Their efferents open into the bronchomediastinal lymph trunk. The *posterior mediastinal lymph glands* lie by the side of the descending thoracic aorta and receive lymph from the pericardium, œsophagus, diaphragm and the upper surface of the liver. Their efferents open mainly into the thoracic duct.

(5) The **bronchial lymph glands** consist of four groups: tracheobronchial, intertracheobronchial, bronchopulmonary, and pnlmonary. The *tracheobronchial lymph glands* lie in the lateral angle between the trachea and bronchus. They receive afferents from the neighbouring portions of the trachea and bronchi; their efferents pass to the bronchomediastinal trunk and to the

inferior deep cervical glands. The *intertracheobronchial lymph glands* lie in the angle between the two main bronchi. They receive afferents from the neighbouring parts; their efferents pass to the tracheobronchial glands. The *bronchopulmonary lymph glands* lie in the hilum of each lung. They receive afferents from the pleura and the substance of the lung; their efferents pass to the tracheobronchial glands. The *pulmonary lymph glands* lie in the substance of the lung on the branches of the bronchi. They receive afferents from the substance of the lung; their efferents pass to the bronchopulmonary glands.

### The Lymphatic Vessels of the Thorax

The **lymphatic vessels of the thorax** consist of two main groups: (1) the vessels of the thoracic wall viz., the intercostal lymphatic vessels and the vessels of the diaphragm; (2) the vessels of the contents of the thorax.

The *intercostal lymphatic vessels* receive lymph from the ribs and intercostal spaces and pass to the sternal and intercostal glands.

The *lymphatic vessels of the diaphragm* end in the diaphragmatic and posterior mediastinal lymph glands.

*Lymphatic vessels of the contents of the thorax.*—The lymphatic vessels of the parietal pleura end in the sternal and intercostal lymph glands; those of the visceral pleura and lung end in the bronchopulmonary glands; those of the pericardium and heart end in the anterior mediastinal glands; those from the thoracic portion of the œsophagus pass to the inferior deep cervical, bronchial and posterior mediastinal glands.

### The Lymph Glands of the Abdomen and Pelvis

The **lymph glands of the abdomen and pelvis** comprise two main groups: the parietal and visceral. The **parietal lymph glands** consist of the following groups: the external iliac, common iliac, lumbar, hypogastric, and sacral. The **visceral lymph glands** consist of the following groups: the inferior mesenteric, superior mesenteric, gastric, hepatic, and pancreaticolienal.

The **external iliac lymph glands**, about ten in number, are arranged on the anterior, medial and lateral sides of the external iliac vessels. Their afferents are derived from the inguinal and subinguinal lymph glands, the deep lymphatic vessels of the abdominal wall below the umbilicus, corresponding to the area of distribution of the inferior epigastric and deep circumflex iliac arteries. Their efferents pass to the common iliac lymph glands. The **common iliac lymph glands**, about six in number, lie behind and on the sides of the common iliac artery; their afferent vessels are derived from the external iliac and hypogastric lymph glands. Their efferents pass into the lumbar lymph glands. The **lumbar lymph glands** consist of four groups—right and left lateral aortic, preaortic, and retroaortic. (1) Those situated in front of and behind the inferior vena cava are called the *right lateral aortic lymph glands.* (2) Those on the left side of the abdominal aorta are called the *left lateral aortic lymph glands.* Both right and left groups receive the efferents of the common iliac lymph glands, the lymph vessels from testes and epididymides (in the male), ovaries, uterine tubes and upper part of the uterus (in the female), the kidneys and surparenal glands and the lateral abdominal muscles. Their efferents form the *right* and *left lumbar lymph trunks* which open into the cisterna chyli. (3) The *preaortic lymph glands* are situated in front of the abdominal aorta and chiefly surround the origins of the cœliac, superior mesenteric and inferior mesenteric arteries. Their afferents are derived from the viscera supplied by these arteries and their efferents unite to form the *intestinal lymph trunk* which opens into the cisterna chyli. (4) The *retroaortic lymph glands* lie below the cisterna chyli; their afferents are derived from the lateral and preaortic lymph glands while their efferents end in the cisterna chyli.

The **hypogastric lymph glands** surround the hypogastric vessels. Their afferents are divided from the area of distribution of the branches of the hypogastric artery. Their efferents pass to the common iliac lymph glands. The **sacral glands** lie along the middle and lateral sacral vessels. Their afferents are derived from the rectum and posterior wall of the pelvis. Their efferents pass to the common iliac lymph glands.

The **inferior mesenteric lymph glands** are divisible into three sets: (1) the *pararectal* set which lies in connection with the muscular layer of the rectum; (2) the *sigmoid* set which lies in connection with the superior hæmorrhoidal artery; and (3) glands which lie in connection with the left colic and sigmoid arteries. They receive afferents from the upper part of the rectum, the sigmoid and the descending colon; their efferents end in the preaortic lymph glands.

The **superior mesenteric lymph glands** are divisible into three sets: (1) the *mesocolic lymph glands* which are numerous and lie between the layers of the transverse mesocolon; (2) the *ileocolic lymph glands* about 16 in number, which lie in connection with the ileocolic artery; and (3) the *mesenteric lymph glands* which are numerous and lie between the layers of the mesentery. They receive afferents from the transverse colon, ascending colon, vermiform process, cæcum, ileum and jejunum; their efferents end in the preaortic lymph glands.

The **gastric lymph glands** are arranged in two sets, the superior and inferior. The *superior gastric lymph glands* consist of three subdivisions: (1) the *paracardial* set which lie around the cardiac orifice of the stomach; (2) the *upper* set which lie on the trunk of the left gastric artery; (3) the *lower* set which lie along the branches of the left gastric artery between the two layers of the lesser oemntum. They receive afferents from the stomach; their efferents end in the preaortic lymph glands. The *inferior gastric lymph glands* lie along the pyloric portion of the greater curvature of the stomach between the two layers of the greater omentum. They receive afferents from the stomach; their efferents end in the subpyloric lymph glands.

The **hepatic lymph glands** consist of two sets, hepatic and subpyloric. The *hepatic set* lies in the region of the porta hepatis between the two layers of the lesser omentum. They receive afferents from the liver; their efferents pass to the preaortic lymph glands. The *subpyloric set* lies between the superior and descending parts of the duodenum.

The **pancreaticolienal lymph glands** lie in connection with the lienal artery and posterior surface of the pancreas. They receive afferents from the spleen and pancreas; their efferents pass to the preaortic lymph glands.

### The Lymphatic Vessels of the Abdomen and Pelvis

The *lymphatic vessels of the parietes of the abdomen* and *pelvis* are subdivided into two groups, superficial and deep. The superficial lymphatic vessels accompany the superficial blood vessels; those from the upper part of the abdominal wall above the umbilicus end in the pectoral group of axillary glands; those from the lower part below the umbilicus end in the superficial subinguinal glands. The deep lymphatic vessels of the anterior abdominal wall follow the main blood vessels; those from the upper part end in sternal glands; those from the lower part end in the external iliac glands. The *lymphatic vessels of the viscera of the abdomen* and *pelvis* consist of: (1) those of the different parts of the digastric tube, (2) those of the liver, spleen and pancreas, (3) those of the genitourinary organs. The lymphatic vessels of the stomach communicate freely with those of the œsophagus and duodenum. They accompany the blood vessels: those accompanying the short gastric and left gastroepiploic arteries pass to the pancreaticolienal lymph glands; those accompanying the left gastric artery pass to the superior gastric lymph glands. The lymphatic vessels of the duodenum pass to the pancreaticoduodenal lymph glands. The lymphatic vessels of the jejunum and ileum are known as *lacteals* or *chyliferous vessels* on account of their containing milky white fluid called chyle; they pass to the mesenteric glands. The lymphatic vessels of the cæcum and vermiform process pass to the ileocolic lymph glands. The lymphatic vessels of the ascending colon and transverse colon end in the mesenteric lymph glands; those of the descending colon and sigmoid colon end in the preaortic lymph glands; those of the rectum end in the pararectal lymph glands; those of the anal canal end in the hypogastric lymph glands; those of the anus end in the superficial subinguinal lymph glands.

The lymphatic vessels of the liver are arranged in two groups: superficial and deep. The superficial vessels arise beneath the peritoneal coat: those from the greater part of the inferior surface of the liver pass to the porta hepatis and end in the hepatic lymph glands. The vessels of the anterior and superior and right lateral surfaces of the liver have different destinations. Of the vessels from the neighbourhood of the falciform ligament some terminate in the anterior set of diaphragmatic lymph glands; others pass to the hepatic lymph glands. The vessels from the right lateral surface and right portion of the superior surface pass to the diaphragmatic lymph glands. The vessels from the left portion of the superior surface pass to the preaortic lymph glands surrounding the cœliac artery. The deep lymphatic vessels of the liver form two sets: some accompany the branches of the portal vein and end in the hepatic lymph glands; others accompany the hepatic veins and end in the lymph glands round the termination of the inferior vena cava.

The lymphatic vessels of the gall bladder and bile duct pass to the hepatic lymph glands. The lymphatic vessels of the spleen and pancreas end in the pancreaticolienal lymph glands. The lymphatic vessels of the kidneys and suprarenal glands end in the lateral aortic lymph glands. The lymphatic vessels of the bladder pass to the hypogastric and external iliac lymph glands. The lymphatic vessels of the penis pass to the proximal set of subinguinal group of lymph glands. The lymphatic vessels of the vagina and uterus end in the following manner: those from the lower part of the vagina pass to the superficial subinguinal glands; those from the upper part of the vagina pass to the hypogastric glands; those from the lower part of the uterus including the cervix pass to the hypogastric glands; those from the fundus and body of the uterus pass to the lateral and preaortic lymph glands.

## The Lymph Glands of the Superior Extremity

The lymph glands of the superior extremity consist of two groups: superficial and deep.

The superficial lymph glands are:—(1) The *deltoideopectoral lymph glands*, one or two in number, lie in the deltoideo-pectoral triangle by the side of the cephalic vein and receive lymph vessels from the lateral side of the arm and from the shoulder. (2) The *supratrochlear lymph glands*, one or two in number, which lie just above the medial epicondyle of the humerus on the medial side of the basilic vein and receive lymphatic vessels from the ulnar side of the forearm and hand including the middle, ring and little fingers—their efferents accompany the basilic vein and drain into the lateral group of axillary lymph glands.

The deep lymph glands are: (1) small glands in relation with the arteries of the forearm; (2) small glands along the course of the brachial artery; (3) axillary lymph glands.

The **axillary lymph glands** (Fig. 240) are situated in the axillary region. They may be arranged into five groups:—(1) The *lateral group* consists of four to six lymph glands and lies along the axillary vein. They drain lymph from the whole of the superior extremity except the lateral side of the arm and shoulder; their efferents open into the central and subclavicular group of lymph glands. (2) The *anterior* or *pectoral group* consists of four or five lymph glands and lies along the lower border of the pectoralis minor along the lateral thoracic artery. They drain lymph from the thoracic wall, and the upper part of the anterior abdominal wall, and the mamma and their efferents open into the central and subclavicular group of lymph glands. (3) The *posterior* or *subscapular group* consists of six or seven lymph glands and lies along the course of the subscapular vessels and drain lymph from the back of the neck and posterior thoracic wall. Their efferents open into the central group of lymph glands. (4) The *central* or *intermediate group* consists of three or four lymph glands embedded in fat near the centre of the base of the axilla. They receive lymph from all the former groups and their efferents open into the subclavicular lymph glands. (5) The *subclavicular group* consists of six or eight lymph glands situated near the apex of the axilla. They receive lymph from all other groups of axillary lymph glands and from the deltoideopectoral group. Their efferents unite to form the *subclavian lymph trunk* which joins the jugular lymph trunk in the neck or may open separately into the junction of the internal jugular and subclavian veins.

## The Lymphatic Vessels of the Superior Extremity

The lymphatic vessels of the superior extremity are arranged in two groups, superficial and deep.

The *superficial lymphatic vessels* lie in the skin and subcutaneous tissues and their main vessels accompany the superficial veins. They commence in cutaneous plexuses. The digital plexuses end in dorsal digital vessels which pass to the dorsum of the hand. From the volar plexus of the hand the vessels pass distally, proximally, medially and laterally and join the vessels in those situations. As the vessels ascend on the volar and dorsal aspects of the wrist they accompany the superficial veins, viz., the basilic, the median antibrachial and cephalic in the forearm. Some of these vessels on the medial side of the forearm pass to the supratrochlear lymph glands while others end in the lateral group of axillary glands. The vessels of the lateral side of the forearm pass to the deltoideopectoral glands, the efferents from which end in the subclavicular group of axillary glands.

The *deep lymphatic vessels* accompany the deep blood vessels and are arranged in five groups which are associated with the radial, ulnar, volar interosseous, dorsal interosseous, and brachial arteries. Usually two lymphatic vessels are found in connection with each artery. These deep vessels communicate with the superficial vessels; some of them end in the lymph glands found along the course of the arteries; others terminate in the lateral group of axillary lymph glands.

### The Lymph Glands of the Inferior Extremity

The lymph glands of the inferior extremity are divisible into two main groups: superficial and deep.

The **superficial lymph glands** are separable into an inguinal group and a subinguinal group. The **inguinal group of lymph glands** practically consists of glands which have dissociated from the subinguinal group and lie above the level of the inguinal ligament. They receive lymphatics from the lower part of the anterior abdominal wall; their efferents pass to the superficial or deep subinguinal glands. The **superficial subinguinal lymph glands** are arranged in two sets, a proximal and a distal; each set is separable into medial and lateral portions. The *proximal set* lies along the line of the inguinal ligament; its lateral portion receives lymphatics from the upper and lateral part of the thigh, and lower and lateral portion of the abdominal wall; its medial portion receives lymphatics from the perineum and the external genitals. The *distal set* lies along the line of the terminal portion of the great saphenous vein (1) on the lateral side and (2) on the medial side of the vein; they receive superficial lymphatics of nearly the whole of the inferior extremity, except the lateral part of the foot and the back of the leg. The efferents of both proximal and distal sets end in the deep subinguinal lymph glands.

The **deep lymph glands** are the anterior tibial, popliteal and deep subinguinal. The **anterior tibial lymph gland** is not constant; it lies in relation with the upper part of the anterior tibial artery.

The **popliteal lymph glands** are six or seven in number. One lies superficially near the termination of the small saphenous vein into the popliteal vein. Its afferents accompany the small saphenous vein draining lymph from the lateral side of the foot and superficial part of the back of the leg. One lies deep between the popliteal artery and the oblique popliteal ligament. Its afferents are the lymphatic vessels from the knee joint and those accompanying the genicular arteries. The remaining four or five glands lie along the sides of the popliteal vessels. Their afferents accompany the anterior and posterior tibial blood vessels. The efferents from all these popliteal lymph glands accompany the femoral vein and drain into the deep subinguinal lymph glands.

The **deep subinguinal lymph glands** lie on the medial side of the femoral vein and vary from one to three in number: one lies in the femoral canal; the second, when present, occupies the femoral ring; and the third lies on the medial side of the femoral vein below its junction with the great saphenous vein. Their afferents are the deep lymphatic vessels accompanying the femoral vessels and also the lymphatic vessels of the penis or clitoris. They also receive the lymphatic vessels which come from the superficial subinguinal lymph glands through the fascia cribrosa. Their efferents drain into the external iliac lymph glands.

## The Lymphatic Vessels of the Inferior Extremity

The lymphatic vessels of the inferior extremity are disposed in two sets, superficial and deep, which freely communicate with each other in certain situations.

The *superficial lymphatic vessels* lie in the superficial fascia. There is a network of vessels on the dorsum of the foot which receives the lymphatics of the toes and of the plantar region. From this dorsal plexus two sets of lymphatic vessels proceed upwards which follow the course of the great saphenous and small saphenous veins respectively. The vessels following the great saphenous vein are numerous and pass to the superficial subinguinal glands. The vessels following the small saphenous vein pass to the popliteal glands.

The *deep lymphatic vessels* accompany the deep blood vessels. In the leg three sets of vessels accompany the two tibial and peroneal arteries and end in the popliteal lymph glands. The deep lymphatic vessels of the proximal parts of the inferior extremity pass to the deep subinguinal glands and the hypogastric gland.

# THE NERVOUS SYSTEM—NEUROLOGY

Both anatomically and physiologically, the nervous system is the most highly developed and definitely distributed of all the systems of the body. It is made up of two chief elements: (1) of the *nerve cells* with their processes called *neurons*, and (2) of *neuroglia* or nerve glue, which is a special kind of supporting connective tissue. The nerve cells become collected in the grey substance of the brain and medulla spinalis. Smaller collections of nerve cells, called *ganglia*, are seen on the sensory cerebral nerves, on the dorsal roots of spinal nerves, and also in connection with the sympathetic nerves. The nerve cells vary in their shape and size and have one or more processes. Nerve cells with one process are called unipolar cells; those with two are called bipolar cells; those with more than two, multipolar cells. The processes are divisible into two kinds: (1) *axis cylinder process* or *axon* which becomes the axis cylinder of the nerve fibre; (2) *dendrons* which divide into numerous branches—the terminal filaments of the processes are called *dendrites*. Each nerve cell with its dendrons and axon forms a *neuron*. There is no continuity of structure between one neuron and another. But impulses from one neuron are transmitted to another neuron situated close by or at a distance by the processes of one neuron arborising in contiguity around the processes of another. This arborisation of the processes of one nerve cell around those of another is called a *synapse*. The method of transmission of nerve impulse from one neuron to another by contiguity of processes and not by continuity of structures was first formulated by Waldeyer and is hence called the *Neuron Theory of Waldeyer*.

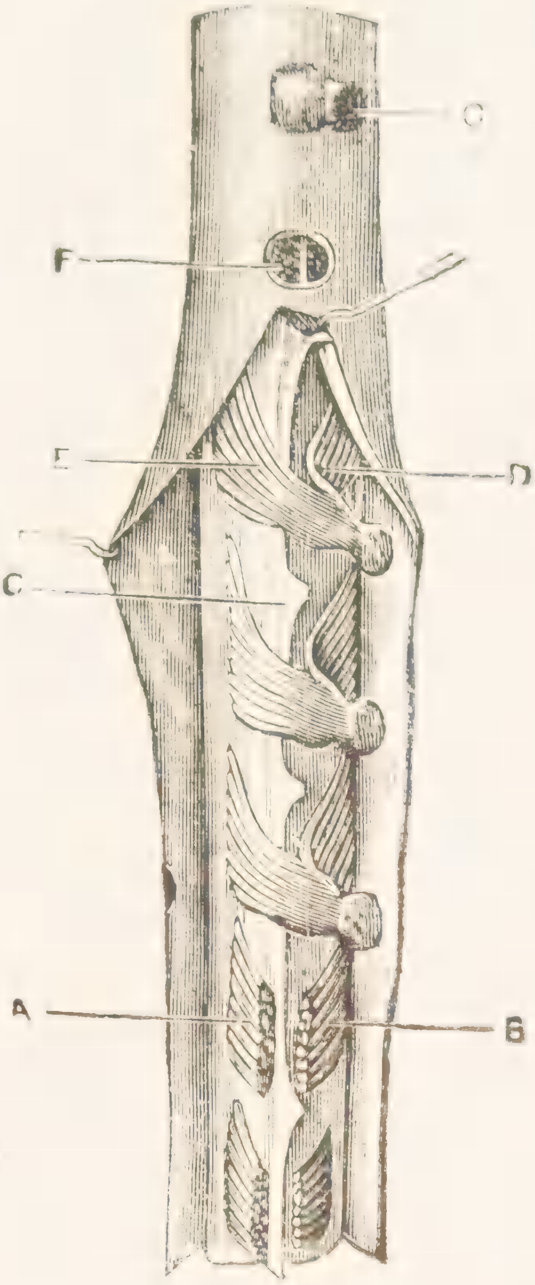
The fibres which form the nerves are arranged in bundles of greater or lesser bulk and are of two kinds: medullated or white fibres and nonmedullated or grey fibres. The *medullated fibres* form the entire mass of white substance of the brain and medulla spinalis and also the nerves attached to the brain and medulla spinalis, with the exception of the olfactory nerve. Each medullated fibre consists of two parts: a central part called the *axis cylinder* which is surrounded by a sheath of fatty nature called the *medullary sheath*. A second sheath, thin and membranous, is placed externally and is called the *primitive sheath* or *neurolemma*. The *nonmedullated fibres* are seen largely in the sympathetic system and in small quantities in the cerebrospinal system. Nerve fibres are also classified into afferent and efferent. The *afferent nerve fibres* convey impulses from the peripheral organs into the central nervous system and as they usually give rise to a sensation, these fibres are also called *sensory*. The *efferent nerve fibres* convey impulses from the central nervous system to the peripheral organs: of these those which go to the muscles are called *motor* ; those which go to the glands are called *secretory* ; those which check movement or secretion are called *inhibitory*.

The nervous system is divided into two main divisions : the cerebrospinal and autonomic systems. It is not an anatomical subdivision of the nervous system but is only a functional differentiation in as much as anatomically the nerve fibres of the two systems are intermingled with one another. The **cerebrospinal nervous system** is composed of two parts, a central and a peripheral. The central part consists of the brain and medulla spinalis which together constitute the **central nervous system** or **cerebrospinal axis.** The peripheral part consists of the cerebral and spinal nerves which are attached to the brain and medulla spinalis respectively and constitute the **peripheral nervous system.** The nervous system controlling the involuntary muscles, blood-vessels, viscera and glands constitutes the **autonomic nervous system** and its action is independent of the control of the will. It also consists of a central and a peripheral part : the central part consists of the ganglia while the peripheral part consists of the branches of communication and distribution. It is subdivided into two secondary systems : the parasympathetic and the sympathetic. These will be fully described in the Section dealing with the autonomic nervous system.

## The Medulla Spinalis

The **medulla spinalis** (spinal cord) (Figs. 250, 251) is that portion of the cerebrospinal axis which occupies the upper two-thirds of the vertebral canal and is about 45 cm. in length and 30 gms. in weight. It is cylindrical in form ande xtends from the lower margin of the foramen magnum to the lower border of the first lumbar vertebra or the upper border of the second lumbar vertebra. Superiorly it is continuous with the medulla oblongata of the brain while inferiorly it terminates in a tapering portion called the *conus medullaris*. From the end of the conus a slender glistening thread, called the *filum terminale*, is prolonged downwards and becomes attached to the back of the first piece of the coccyx. The medulla spinalis is enclosed by three protective membranes. These membranes are termed from without inwards the dura mater, the arachnoid, and the pia mater and will be described in detail in the Section on the meninges of the brain and medulla spinalis.

The **filum terminale** (Fig. 251) is the slender filament prolonged from the tip of the conus medullaris and is placed in the middle of the bunch of nerves called the *cauda equina* but it can be easily distinguished from them by its silvery colour and by its terminating in the conus medullaris. It is about 6 inches long and consists chiefly of pia mater. Its upper part encloses a small amount of nervous substance and the central canal of the medulla spinalis is prolonged down into its upper part. Opposite the lower border of the second sacral vertebra it pierces the tube of dura mater and receives an adherent sheath from it. Then it descends to be blended with the periosteum covering the back part of the coccyx. The upper portion of it within the tube of dura mater is called the *filum terminale internum* and the lower portion with the adherent sheath of the dura mater is called the *filum terminale externum.*



A. B. Fasciculi of origin of nerve roots.

C. Ligamentum denticulatum.

D. Anterior nerve root.

E. Posterior nerve root.

F. Section through nerve roots.

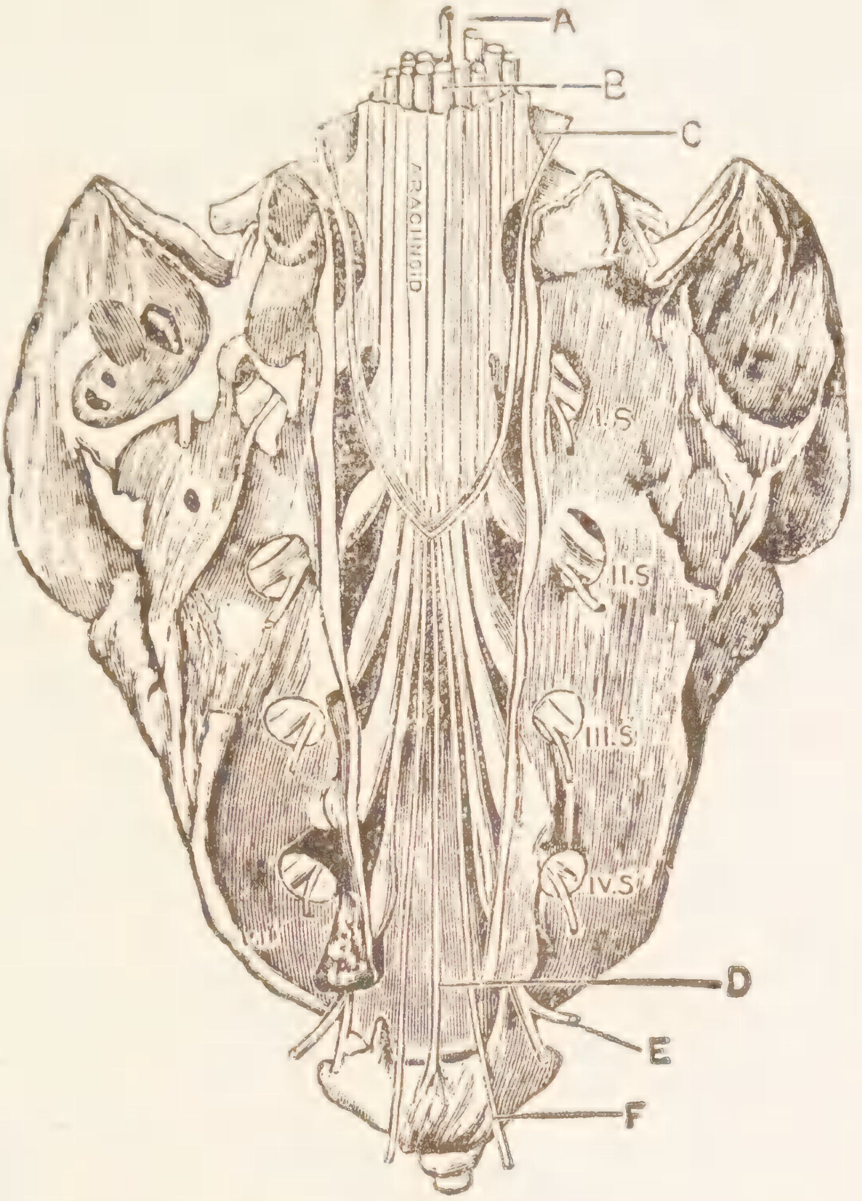
G. Spinal nerve with its sheath of dura mater.

Fig. 250.—Lateral view of the medulla spinalis showing dura mater, ligamentum denticulatum, and anterior and posterior nerve roots.

**Spinal nerves.**—Thirty one pairs of spinal nerves arise from the sides of the medulla spinalis. They are arranged on either side in five groups : eight cervical, twelve thoracic, five lumbar, five sacral, and one coccygeal. Each spinal nerve is attached to the organ by two roots, anterior and posterior. Each root consists of several nerve fascicles or bundles which spread out at the side of the organ. The portion of the medulla spinalis from which each pair of spinal nerves arise is called a *spinal segment* or *neuromere.*

**Enlargements.**—In the thoracic region the medulla spinalis presents almost an uniform outline but in the cervical and lumbar regions it shows swellings. The *cervical enlargement* extends from the level of the third cervical vertebra to the first or second thoracic vertebra ; to it are attached the great nerves of the upper limbs. The *lumbar enlargement* lies opposite the last three thoracic vertebræ ; to it are attached the great nerves of the lower limbs.

**Fissures and sulci** (Fig. 252).—The *anteromedian fissure* lies vertically along the median line on the anterior surface and penetrates into the organ for one third of its thickness. It contains a double fold or reduplication of the pia mater and at its bottom is a transverse band of white substance called the *anterior white commissure* which connects the white substance of the two halves of the organ. The *posteromedian sulcus* lies vertically on the posterior surface of the medulla spinalis along the median line. It is very shallow and from its bottom a septum of neuroglia called the *posteromedian septum*, passes into the transverse band of grey substance, called the *posterior grey commissure*, which connects the two halves of the grey substance. The *posterolateral sulcus* lies on either side of the posteromedian sulcus and gives attachment to the fila of the posterior nerve-roots along a continuous straight line.



A. Filum terminale.
B. Cauda equina.
C. Dura mater.
D. Filum terminale.
E. Fifth sacral nerve.
F. Coccygeal nerve.

Fig. 251.—Sacral canal laid open from behind, showing the cauda equina and the filum terminale.

**Regions of the medulla spinalis.**—By these three sulci the surface of each half of the medulla spinalis is divided into two regions: (1) the *anterolateral region* which lies between the anteromedian fissure and the posterolateral sulcus and gives attachment to the fila of the anterior nerve roots—these fila are attached not in a straight line but irregularly, extending over an area of some width; (2) the *posterior funiculus* which lies between the posteromedian and posterolateral sulci. Each of these regions is again subdivided into two parts. Thus the anterolateral region is subdivided into an *anterior funiculus* and a *lateral funiculus*—the two being separated by the line of attachment of the most lateral fila of the anterior nerve roots. The posterior funiculus is subdivided by a longitudinal faint groove called the *postero-intermediate sulcus*, into the posteromedian funiculus (column of Goll) which lies between the posteromedian and postero-intermediate sulci and the *posterolateral funiculus* (column of Burdach) which lies between the postero-intermediate and posterolateral sulci; the postero-intermediate sulcus which lies between the posteromedian and posterolateral sulci can be traced only in the cervical and thoracic regions.

*Mode of distinguishing the anterior from the posterior surface of the medulla spinalis.*—

| *Anterior surface.* | *Posterior surface.* |
|---|---|
| 1. Linea splendens in the middle line. | 1. Presence of a shallow posteromedian sulcus. |
| 2. Presence of a deep anteromedian fissure. | 2. Posterolateral arterial trunks in relation to the posterior nerve roots. |
| 3. Single anterior spinal artery in the median line. | 3. Posterior nerve roots larger than anterior, and provided with ganglia—their fila enter in a straight line through posterolateral sulcus. |
| 4. Anterior nerve roots, smaller than posterior—their fila emerge not in a straight line but are spread irregularly over a wide area. | |

**Internal structure of the medulla spinalis** (Fig. 252).—The medulla spinalis consists of white substance externally and grey substance internally.

**Grey substance.**—In a transverse section the grey substance presents the appearance of two comma-shaped masses the convexities of which are directed towards each other. These are connected together by a transverse band of grey substance called the *grey commissure*. These masses together with the transverse grey commissure present the shape of the letter **H**. Through the grey commissure a minute canal, called the *central canal*, is just visible to the naked eye. The portion of the grey commissure lying in front of the central canal is called the *anterior grey commissure* and that behind it is called the *posterior grey commissure*. The posteromedian septum reaches the posterior grey commissure but the bottom of anteromedian fissure is separated from the anterior grey commissure by a band of white substance called the *anterior white commissure*.

Each comma-shaped mass of grey substance is divisible into an anterior column lying in front of the grey commissure and a posterior column lying behind it. The *anterior column* (anterior cornu) is short, thick and rounded and is separated from the surface of the spinal medulla by white substance through which the fila of the anterior nerve-roots pass to the surface.

Its enlarged extremity is called the *head*; the constricted portion is called the *neck;* and the posterior portion is called the *base*. In the thoracic region and especially in its upper part a triangular projection is seen projecting lateralwards from the base of the anterior column, and is called the *lateral column* (lateral crown). When traced into lower cervical and lumber regions this projection blends with the anterior column but manifests itself again above the level of the fourth cervical vertebera. The *posterior column* (posterior cornu) is long and narrow; it presents a slight enlargement near the posterolateral sulcus called the *head*. The head tapers to a pointed extremity called the *apex* with which the fila of the posterior nerve roots are continuous. In front of the head is a slight constriction called the *neck* and in front of the neck is the *base* which is continuous with the base of the anterior column. Surrounding the apex of the posterior grey column is a translucent mass of cells mostly of gelatinous neuroglia and is called the *substantia gelatinosa of Rolando*. The shape and size of the grey substance varies in different regions of the medulla spinalis. In the cervical region of the medulla spinalis where the cervical nerves are attached, the grey substance of the anterior column is seen to be much enlarged and the posterior column though enlarged is thinner than the anterior. In the thoracic segment of the medulla spinalis corresponding to the attachments of the thoracic nerves both the anterior and posterior columns are much attenuated. The presence of the lateral column in the thoracic segment has been already referred to. In the lumbar segment of the medulla spinalis corresponding to the attachments of the lumbar nerves both the columns of grey substance are enlarged—specially the posterior one so that the difference between the anterior and posterior columns are less distinct. In the conus medullaris corresponding to the attachments of the sacral nerves the grey substance assumes an oval shape on either side connected together by a broad grey commissure.

The **central canal** runs throughout the entire length of the medulla spinalis. Below, the canal is continued for a short distance into the filum terminale; above, it traverses the lower part of the medulla oblongata and opens into the fourth ventricle of the brain. In the lower part of the conus medullaris it presents a fusiform dilatation called the *terminal ventricle*. In the cervical and thoracic segments of the medulla spinalis the central canal is nearer to its anterior surface. In the lumbar enlargement the canal is in the centre whereas in the conus medullaris it is nearer the posterior surface of the medulla spinalis. The central canal is surrounded by a stratum of gelatinous substance called the *substantia gelatinosa centralis*.

**Structure of the grey substance.**—The grey substance of the medulla spinalis (Fig. 253) consists of neuroglia, nerve cells and nerve fibres. The **neuroglia** forms a bed in which the nervous elements are distributed; it also isolates the nervous elements from each other but at the same time binds them together. It is of a sponge like consistency throughout but is thicker around the central canal forming the substantia gelatinosa centralis and on the apex of the posterior column forming the substantia gelatinosa of Rolando. The **nerve cells** are present in large numbers and are all multipolar. In transverse sections of the medulla spinalis they are seen to be arranged in groups in certain districts of the grey matter. These groups of cells are arranged in longitudinal columns of varying lengths. These cell columns or groups are mainly three in number viz. (1) in the anterior column of grey substance; (2) in the lateral column of grey substance, when this exists; (3) in the posterior column of grey substance. In addition there are other nerve cells which are not arranged regularly in groups but are scattered irregularly throughout the other portions of the grey substance.

The **nerve cells in the anterior column** are arranged in the following manner:—(*a*) The *anteromedian column* extends downwards up to the fourth lumbar segment of the medulla spinalis; (*b*) the *posteromedian column* lies behind the preceding and extends from the fifth cervical to the first lumbar segment. In the cervical and lumbar enlargements where the anterior column is expanded laterally four additional columns of nerve cells are seen: viz anterolateral, posterolateral, retroposterolateral and central. The axis cylinder processes of all these cells emerge from the surface of the medulla spinalis as filaments of the anterior nerve roots.

The **nerve cells in the lateral column** form a slender column, called the *intermediolateral cell-column,* which extends from the last cervical segment to the second lumbar segment and is best marked in the thoracic region. Fibres from most of these cells pass with the fibres of the anterior nerve roots into the sympathetic ganglia of which they form the white rami communicantes; fibres from a few of these cells pass longitudinally in the anterior and lateral funiculi.

The **nerve cells in the posterior column** form a conspicuous group occupying the medial part of the base of the posterior column. This group is known as the *dorsal nucleus* (Clarke's column) and extends from the level of the last cervical nerve to that of the second lumbar nerve. The fibres from most of these cells pass into the lateral funiculus of the same side to ascend as the direct cerebellar tract; while fibres from some cells pass to the opposite side to ascend as the superficial anterolateral fasciculus.

The **nerve fibres** in the grey matter form a dense network around the nerve cells and are both medullated and nonmedullated. They are derived from the axons of the nerve cells of the columns before they enter the white fasciculi or emerge as the anterior nerve roots and also from the collaterals from the nerve fibres in the white fasciculi.

**White substance** (Figs. 252, 253).—The white substance of medulla spinalis is composed of medullated nerve fibres

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embedded in neuroglia. It increases steadily from below upwards reaching the maximum in the cervical region. Thus although the amount of grey substance is greater than the white in the conus medullaris, the proportion of grey to white in the cervical region is 1 : 5. The nerve fibres are either large or small; some run transversely but the majority take a longitudinal course and connect (1) the medulla spinalis with the brain, or (2) the different segments of the medulla spinalis—constituting the intersegmental or association fibres. The nerve fibres are arranged in three columns or funiculi called the anterior, lateral and posterior. Each funiculus is broken up into smaller tracts or fasciculi of ascending and descending nerve fibres—these fasciuli are called by special names.

**Anterior funiculus.**—The fasciculi in the anterior funiculus are:

(1) The *fasciculus cerebro-spinalis anterior* (**direct pyramidal tract**) lies on either side close to the anteromedian fissure. The fibres of this fasciculus come from the motor area of the same side of the cerebral cortex and pursue a downward path as low as the pyramid of the medulla oblongata of the same side and take no part in the decussation of the pyramids. They, however, cross to the opposite side at regular intervals during their descent and the crossing takes place in the anterior white commissure. The fibres terminate around the nerve cells of the anterior column of grey matter of the opposite side of the medulla spinalis. Thus the tract gradually becomes thinner and disappears towards the lower thoracic region. The decussations of the direct pyramidsal tracts constitute the *spinal* or *inferior motor decussation.*

(2) The *vestibulospinal fasciculus* is situated near the anterior margin of the anterior funiculus. Its fibres are derived from the Deiter's nucleus which is one of the nuclei of the vestibular nerve. The fibres terminate by arborising around the cells of the anterior column of grey substance.

(3) The *anterior spinothalamic fasciculus* lies on either side of the anteromedian fissure. Its fibres originate from the cells of the posterior column of grey substance of the opposite side of the medulla spinalis. The fibres having crossed to the opposite side in the anterior white commissure ascend along the superficial anterolateral fasciculus, traverse the medulla oblongata and pons and end in the thalamus. The fibres of this fasciculus, therefore, give rise to the *spinal* or *inferior sensory decussation.*

(4) A small strand, the *sulcomarginal fasciculus,* borders upon the anteromedian fissure.

(5) The *fasciculus proprius anterior* (anterior basis bundle) consists of association fibres which connect the cells of the anterior grey column in one segment of the medulla spinalis with those of the segment or segments situated above. Some of the fibres of this fasciculus are continued upwards as far as the hypothalamus under the name of the *medial (posterior) longitudinal fasciculus.*

**Lateral funiculus.**—The fasciculi in the lateral funiculus are grouped as ascending and descending. The **ascending fasciculi** are:

(1) The *fasciculus spinocerebellaris posterior* (**direct cerebellar tract of Flechsig**) lies superficially at the back part of the lateral funiculus; its fibres are the axons of the cells of the dorsal nucleus; it begins from the level of the third lumbar nerve, gradually increases upwards and ultimately passing through the restiform body ends in the cerebellum.

(2) The *superficial anterolateral fasciculus* (tract of Gowers) lies superficially in front of the former fasciculus; its fibres are derived from the cells of the dorsal nucleus of the opposite side of the medulla spinalis and extends upwards from the level of the third lumbar nerve through the medulla oblongata, pons and then through the brachium conjunctivum to terminate in the vermis of the cerebellum. It consists of three strands: (*a*) *spinotectal strand* which ends in the corpora quadrigemina; (*b*) *lateral spinothalamic strand* which conveys impulses of touch and temperature to the thalamus; (*c*) *anterior spinocerebellar strand* which reaches the cerebelleum through the brachium conjunctivum.

(3) The *fasciculus of Lissauer* is situated between the substantia gelatinosa of Rolando and the surface of the medulla spinalis, close to the posterolateral sulcus. Its fibres are derived from the lateral fibres of the posterior nerve roots and are intersegmental in character.

(4) The *fasciculus proprius lateralis* (lateral basis bundle) is contiuuous in front with the fasciculus proprius anterior; its fibres are intersegmental in character binding two or more segments of the spinal medulla together. Some of the fibres of this fasciculus are continued upwards in the medial longitudinal fasciculus.

The **descending fasciculi** are:—(1) The *fascicu cerebrospinalis lateralis* (**crossed pyramidal tract**) lies betwe the fasciculus spinocerebellaris and the posterior grey colum ; the fibres of this fasciculus arise from the pyramidal cells in t motor area of the cerebral cortex of the opposite side and assing downwards decussate at the lower part of the medulla oblongata. As the fasciculus descends down the medulla spinalis fibres from it pass successively to enter and end at different levels by arborizing around the cells of the posterior column from which they are linked to the cells of the anterior column by fresh fibres.

(2) The *rubrospinal fasciculus* (Monakow's bundle) lies in front of the lateral cerebrospinal fasciculus and is triangular on transverse section; its fibres are derived from the cells of the red nucleus of the opposite side of the mid-brain, and terminate in the posterior part of the anterior column of grey matter.

(3) The *tectospinal fasciculus* arises from the superior colliculus of the opposite side and ends around the cells in the anterior column.

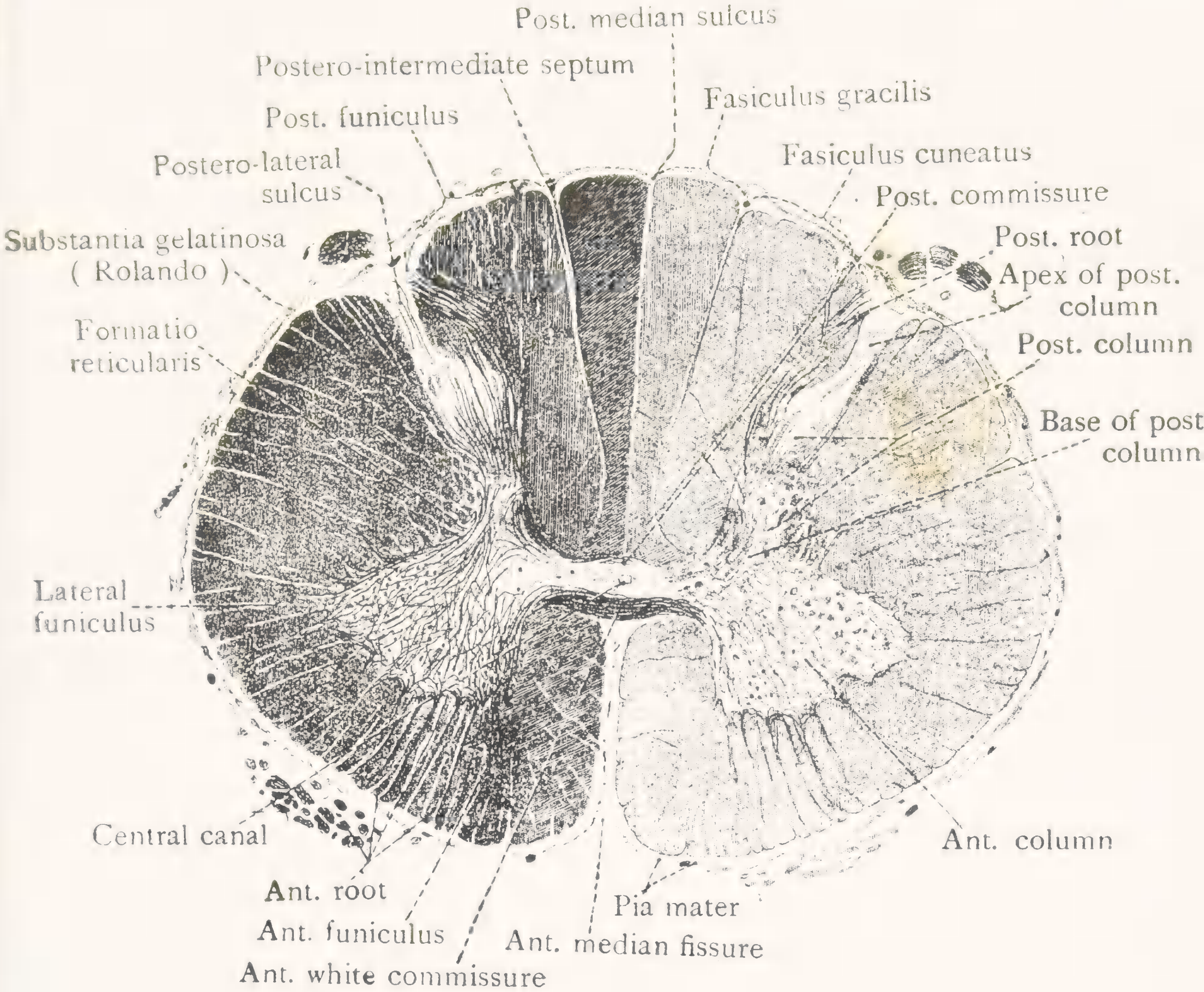

Fig. 252.—Transverse section of the medulla spinalis.

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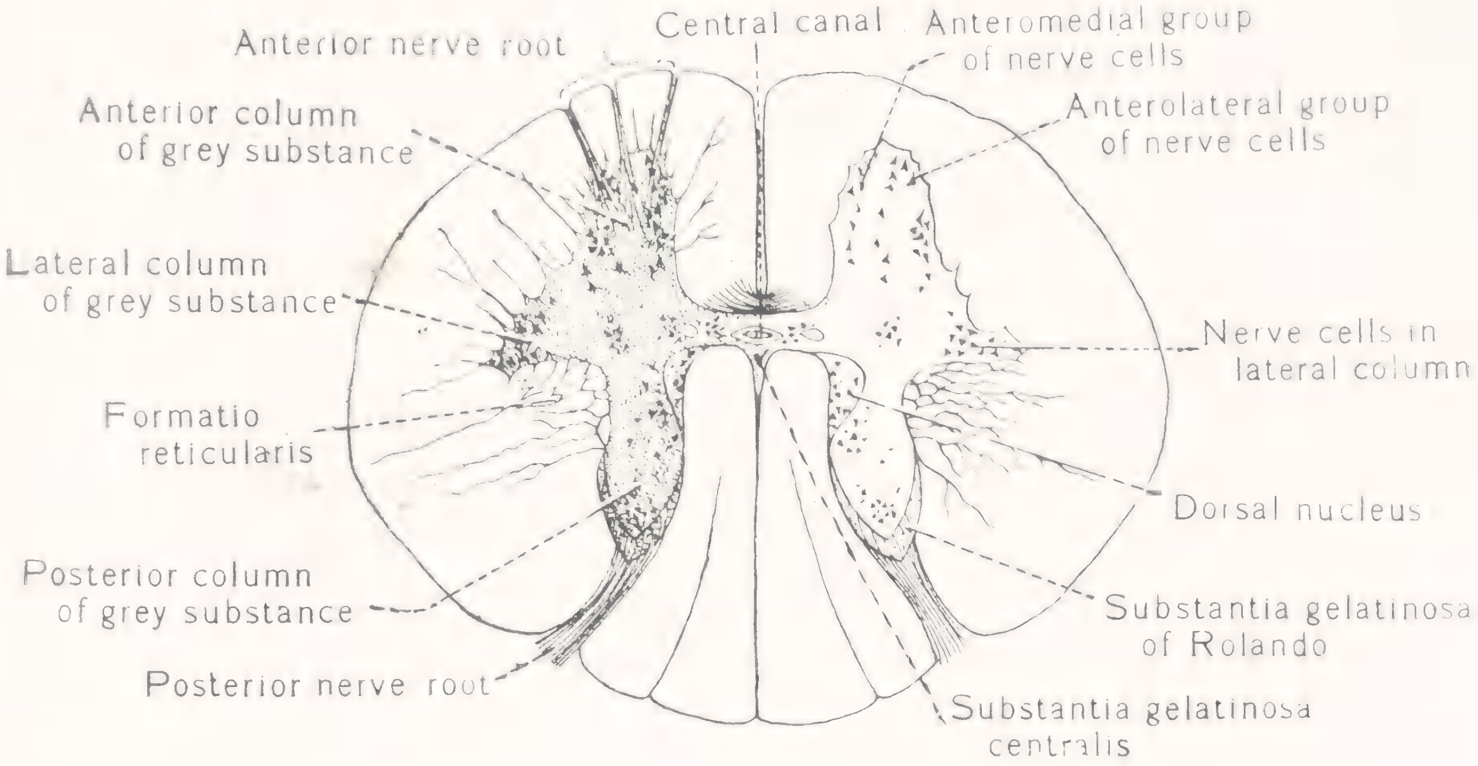
Anterior nerve root
Central canal
Anteromedial group of nerve cells
Anterior column of grey substance
Anterolateral group of nerve cells
Lateral column of grey substance
Nerve cells in lateral column
Formatio reticularis
Dorsal nucleus
Posterior column of grey substance
Substantia gelatinosa of Rolando
Posterior nerve root
Substantia gelatinosa centralis

Fig. 253.—Diagram showing the distribution of the nervecells in the grey substance of the medulla spinalis.

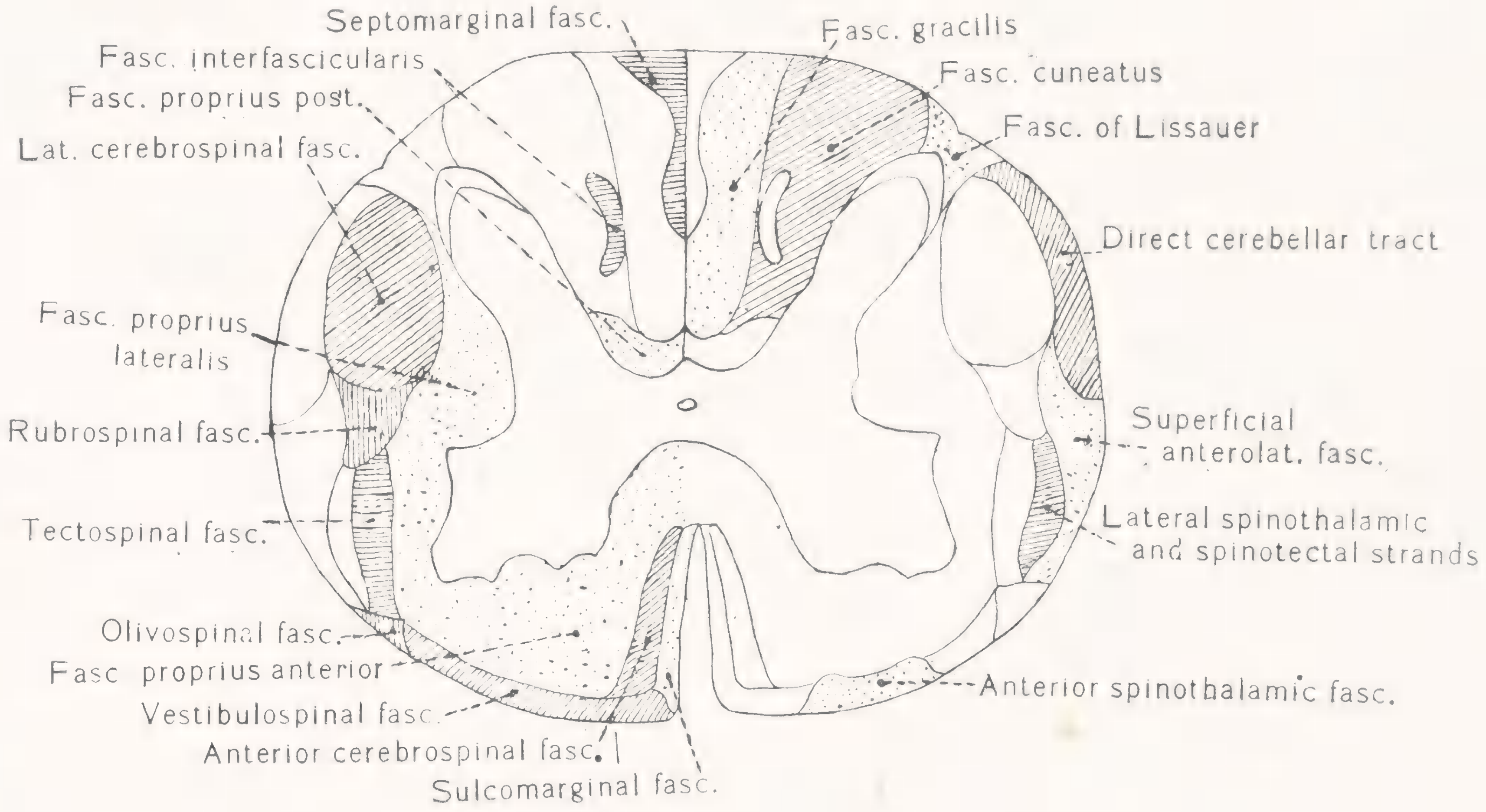

Fig. 253A.—Diagram of the white substance of the medulla spinalis.

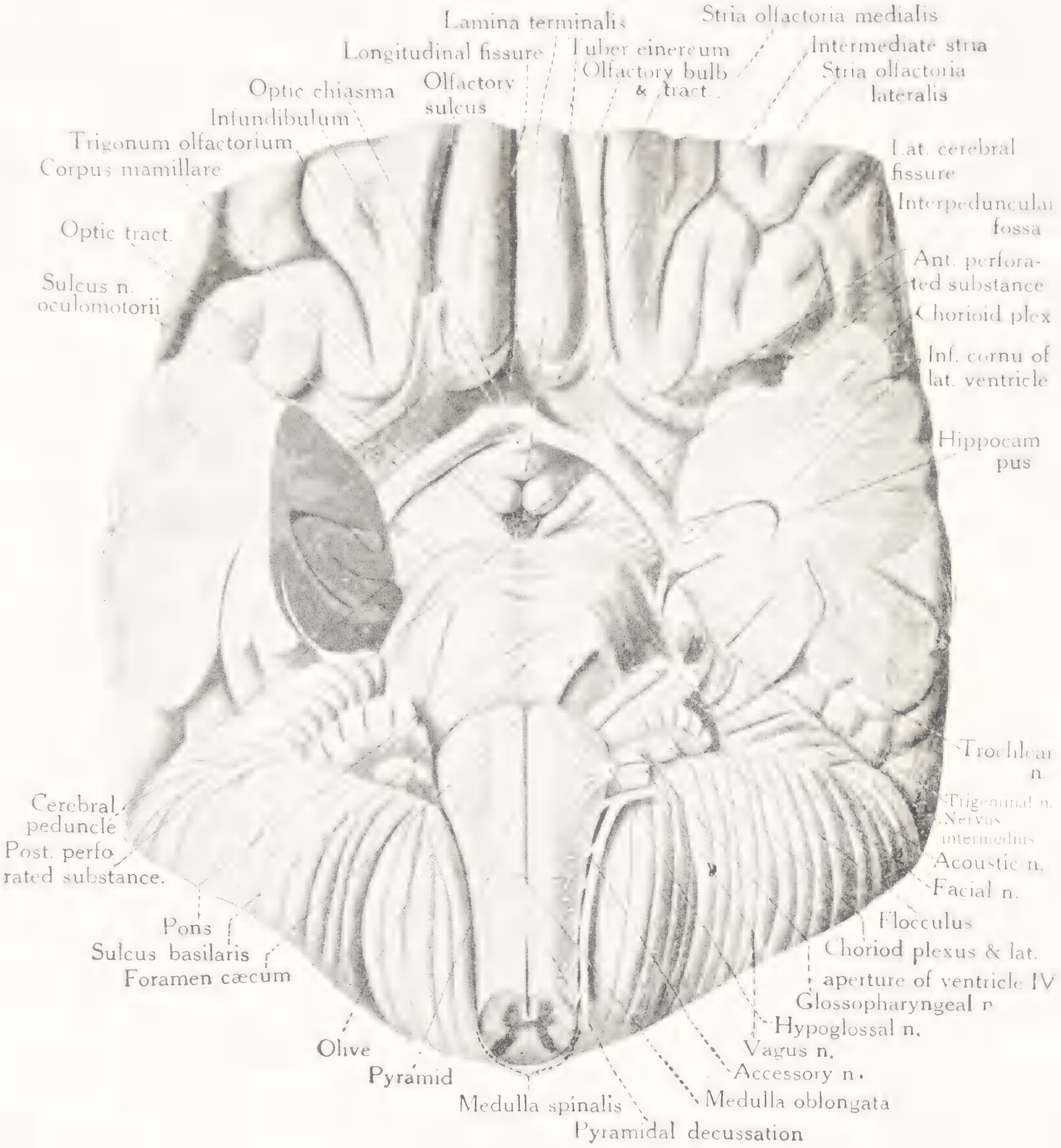

Fig. 254.—Front view of the medulla oblongata, pons and mesencephalon.

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(4) The *olivospinal fasciculus* (bundle of Helweg) is triangular on transverse section; it begins from the inferior olivary nucleus of the medulla oblongata; it is present only in the cervical region and lies just on the outer side of the anterior nerve roots.

**Posterior funiculus.**—The fasciculi in the posterior funiculus are grouped as ascending and descending. The **ascending fasciculi** are:—(1) The *fasciculus gracilis* (tract of Goll) lies on either side of the posteromedian septum and is triangular on transverse section. Its fibres are derived from the posterior nerve roots of the lower thoracic, lumbar, sacral and coccygeal nerves. It increases as it ascends and ultimately ends in the nucleus gracilis in the medulla oblongata. (2) The *fasciculus cuneatus* (tract of Burdach) is situated lateral to the above and is also triangular on transverse section. Its fibres are derived from the posterior nerve roots of the upper thoracic and cervical nerves and ultimately end in the nucleus cuneatus and nucleus gracilis.

The **descending tracts** of the posterior funiculus are:—(1) The *fasciculus interfascicularis* (comma tract of Schultze) is situated in the cervical and upper thoracic regions between the fasciculus gracilis and fasciculus cuneatus and is formed by the descending branches of the posterior nerve roots. Another view is that the fibres of the comma tract are intersegmental and derived from cells in the posterior column and in support of this view it is affirmed that this tract does not undergo degeneration when the posterior nerve roots are severed. (2) Some descending fibres are situated, in the lower thoracic region, on the posterior surface of the funiculus; others, in the lumbar region, on the side of the posterior median septum; others, in the conus medullaris—all these fibres are collectively named the *septomarginal fasciculus*. (3) The *fasciculus proprius posterior* (posterior basis bundle) is situated between the posterior funiculus and posterior grey commissure; its fibres are intersegmental in character.

**Fibres of roots of spinal nerves.**—The fibres of the *anterior nerve roots* are formed mainly by the axis cylinder processes of the cells in the anterior grey column; a few of the fibres are efferent autonomic fibres derived from the cells in the lateral grey column. They appear on the surface over an area corresponding to the head of the anterior column. The fibres of the *posterior nerve roots* arise from the unipolar cells in the spinal ganglia, the axis cylinder processes of which are **T** shaped, half of the horizontal limb of which is central and enters the medulla spinalis along the posterolateral sulcus, while the other half is peripheral and passes outwards with the nerve. On entering the medulla spinalis the posterior nerve root divides within the fasciculus cuneatus into two branches—descending and ascending. The descending branches after a short course, enter the grey substance. The ascending branches are of varying lengths; some enter the grey substance of the medulla spinalis at varying intervals to end around the nerve cells in the columns, while others pass up the fasciculus gracilis and cuneatus to end around the cells of the nucleus gracilis and nucleus cuneatus in the medulla oblongata. These ascending fibres as they pass upwards are gradually reinforced by fresh fibres of the posterior roots at higher levels of the medulla spinalis so that the fibres derived from the posterior roots at the lower part are more and more displaced towards the central line while these from the higher level successively occupy the peripheral position. The ascending and descending branches give off numerous collaterals which enter the anterior and posterior grey columns.

### Table of White Tracts of the Medulla Spinalis

| | Descending Tracts. | Ascending Tracts. |
|---|---|---|
| I. Anterior funiculus | 1. Fasciculus cerebro spinalis anterior | 1. Vestibulospinal fasciculus |
| | 2. Sulcomarginal fasciculus | 2. Anterior spinothalamic fasciculus. |
| | | 3. Fasciculus proprius anterior |
| II. Lateral funiculus | 1. Fasciculus cerebrospinalis lateralis | 1. Fasciculus spinocerebellaris posterior |
| | 2. Rubrospinal fasciculus | 2. Superficial anterolateral fasciculus |
| | 3. Tectospinal fasciculus | 3. Fasciculus of Lissauer |
| | 4. Olivospinal fasciculus | 4. Fasciculus proprius lateralis |
| III. Posterior funiculus | 1. Fasciculus interfascicularis | 1. Fasciculus gracilis |
| | 2. Septomarginal fasciculus | 2. Fasciculus cuneatus |
| | 3. Fasciculus proprius posterior | Mixed tract |

**Arteries of the medulla spinalis.**—There are five arterial trunks running longitudinally along the medulla spinalis. One runs downwards longitudinally along the anteromedian fissure beneath the linea splendens and is called the *anteromedian spinal artery*. It is formed near the foramen magnum by the union of the two anterior spinal branches of the vertebral artery. It is reinforced in the different regions by the spinal arteries. In the cervical region these spinal arteries come from the vertebral and ascending cervical arteries and the arteria profunda cervicis; in the thoracic region, from the posterior branches of the intercostal arteries; in the lumbar region, from the posterior branches of the lumbar arteries; in the sacral region, from the lateral sacral arteries. In this manner the anteromedian artery is prolonged for some distance into the filum terminale. The *posterolateral longitudinal trunks* are four in number, two on each side, one lying in front of and the other behind the attachment of the posterior nerve roots. They begin as the right and left posterior spinal branches of the vertebral artery in the foramen magnum. Each branch bifurcates: one passing in front of and the other behind the posterior nerve roots. These bifurcating branches are reinforced in the different regions by the spinal arteries derived from the same sources as in the case of the anteromedian artery. The posterolateral trunks terminate at the lower end of the medulla spinalis and are not prolonged over the filum terminale. Of the spinal arteries in the different regions, some go to join the anteromedian artery and the rest join the posterolateral arteries, and when a lateral spinal artery gives a branch to the former it does not send another branch to the latter.

**Veins of the medulla spinalis.**—These form plexuses on the surface of the medulla spinalis. Six longitudinal trunks can be recognised amongst these plexuses; one runs along the anteromedian fissure beneath the arterial trunk. Another runs along the posteromedian fissure. The other four run laterally, two on each side, one in front of and the other behind the posterior nerve roots. These trunks communicate freely with each other and send branches laterally along the nerve roots to join the internal vertebral venous plexuses.

## THE ENCEPHALON OR BRAIN

The mass of nervous matter contained in the cavity of the cranium is known as the brain. It is advantageously divided into three parts on the basis of its development from three embryonic brain vesicles. These three primary vesicles are demarcated from each other by constrictions and are called the *rhombencephalon* or *hind-brain*, the *mesencephalon* or *mid-brain* and the *prosencephalon* or *fore-brain*. From the rhombencephalon are formed the medulla oblongata, pons and cerebellum and the cavity inside it becomes the fourth ventricle. From the mesencephalon are formed the corpora quadrigemina and the cerebral peduncles and the cavity inside it becomes the cerebral aqueduct which is the communicating passage between the third and fourth ventricles. The prosencephalon subdivides into two portions: the anterior portion or *telencephalon* forms two vesicles from which are developed the cerebral hemispheres while the cavities of the vesicles become the lateral ventricles; from the posterior portion or *diencephalon* are developed the structures bounding the third ventricle while its cavity forms the greater part of the third ventricle.

## THE RHOMBENCEPHALON OR HIND-BRAIN

The rhombencephalon or hind brain lies below the tentorium cerebelli and occupies the posterior cranial fossa. It consists of the medulla oblongata, the pons, and the cerebellum including the fourth ventricle and the isthmus rhombencephali.

The **medulla oblongata** (Figs. 254, 255) is the most complicated portion of the central nervous system and is in reality the expanded upper end of the medulla spinalis. It extends from the lower margin of the pons to the level of the lower margin of the foramen magnum, where it becomes continuous with the medulla spinalis. It is a little more than an inch in length, three fourths of an inch wide at its broadest part, and half an inch in thickness. Its anterior surface rests in the groove on the basilar portion of the occipital bone. Its posterior surface lies in the fossa between the hemispheres of the cerebellum and forms the lower part of the floor of the fourth ventricle. Its lateral surfaces are in relation with the vertebral artery. The lower half of the medulla oblongata contains the continuation of the central canal of the spinal medulla and is called the *closed part of the medulla oblongata*; the upper half, above the opening of the central canal, contains the lower part of the fourth ventricle and is called the *open part of the medulla oblongata.*

**Fissures** on the surface of the medulla oblongata.—The *anteromedian fissure* is continuous below with the anteromedian fissure of the medulla spinalis and ends above at the lower border of the pons in a cul-de-sac called the *foramen caecum.* It is interrupted at its lower part by some strands of fibres which cross from one side to the other. This intercrossing of fibres is called the *pyramidal decussation.* Above the decussating fibres, some fibres issue from this fissure and proceed lateralwards over the surface of the medulla oblongata ; these are called the *external arcuate fibres.* The *posteromedian fissure* is shallower and continuous with the posteromedian fissure of the medulla spinalis ; it is present only on the lower half of the medulla oblongata, because it ceases at the lower end of the fourth ventricle. The attachment of the fila of the hypoglossal nerve along a continuous straight line marks the position of a faint groove called the *anterolateral sulcus ;* this line of attachment is continuous with the line of the anterior roots of the medulla spinalis. The attachments of the fila of the glossopharyngeal, vagus, and accessory nerves in a line indicate the position of another faint groove called the *posterolateral sulcus*; this line is continuous with the line of the posterior roots of the medulla spinalis.

**Regions** of the medulla oblongata.—The medulla oblongata is divided into two halves by the anteromedian and posteromedian fissures. The surface of each half is again subdivided by the anterolateral and posterolateral sulci into three regions viz., anterior, lateral, and posterior. These three regions appear at first sight to be direct continuations upwards of the three funiculi of the medulla spinalis but really this is not the case—what actually happens is that the fibres of the three funiculi of the medulla spinalis undergo a rearrangement as they proceed upwards into the medulla oblongata.

The **anterior region** or **pyramid** constitutes that portion of the medulla oblongata which is included between the anteromedian fissure and the anterolateral sulcus. It is narrow below but it expands as it passes upwards and again becomes constricted at the lower border of the pons and enters into that structure; the abducent nerve emerges between it and the lower border of the pons. At the lower part the fibres of the medial two-thirds of each pyramid cross to the opposite side forming the *pyramidal decussation* or *superior motor decussation*. These fibres after crossing the middle line proceed downwards in the posterior part of the lateral funiculus of the medulla spinalis as the lateral cerebrospinal fasciculus. The remaining fibres of the lateral third of the pyramid is continued down into the anterior funiculus of the medulla spinalis of the same side as the anterior cerebrospinal fasciculus.

The **lateral region** is situated between the anterolateral sulcus containing the roots of the hypoglossal nerve and the posterolateral sulcus containing the roots of the glossopharyngeal, vagus, and accessory nerves. In the lower part of the medulla oblongata it appears as a continuation of the lateral funiculus of the spinal medulla; in its upper part, a conspicuous oval eminence bulges out on its surface called the *olive*. The olive is about half an inch in length and is separated from the lower border of the pons by a groove where the facial nerve is

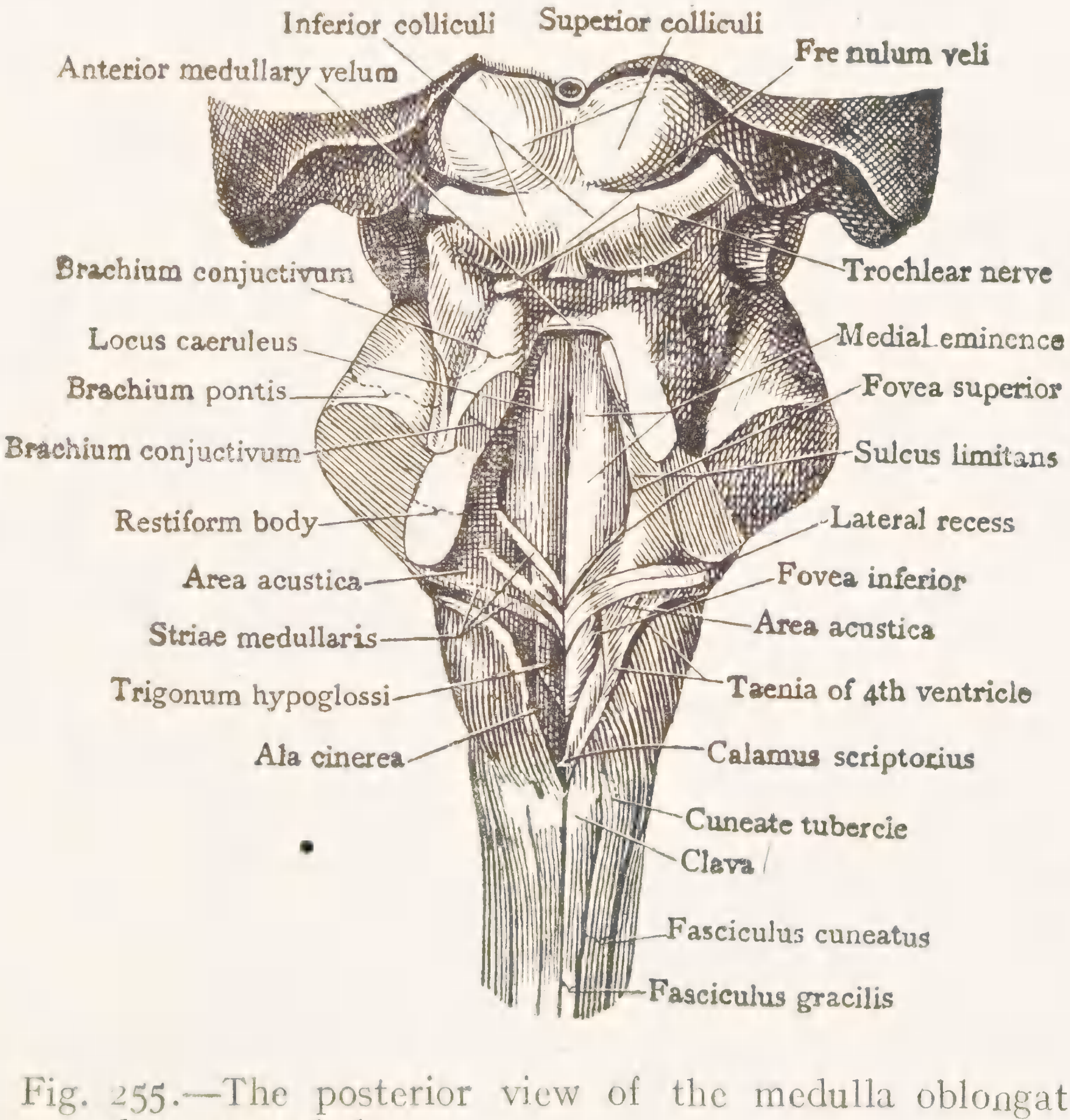

Fig. 255.—The posterior view of the medulla oblongata, pons, and mesencephalon.

attached. The olive marks the position of an underlying mass of grey substance called the *inferior olivary nucleus.* Behind the olive and between it and the posterolateral sulcus is seen an attenuated continuation upwards of the lateral region. In as much as the lateral cerebrospinal fasciculus passes into the pyramid of the opposite side and the fasciculus spinocerebellaris posterior joins the restiform body, it follows therefore that a very small portion of the lateral funiculus of the medulla spinalis is prolonged upwards into the lateral region of the medulla oblongata. This narrow strand passes upwards between the olive and the posterolateral sulcus. Some arched fibres, called the *external arcuate fibres,* emerge from the anteromedian fissure, curve backwards over the pyramid and olive and enter the restiform body.

The **posterior region** is included between (1) the posteromedian fissure and (2) the posterolateral sulcus and by the lateral margin of the medullary part of the floor of the fourth ventricle. It is divisible into a lower and an upper part.

At the **lower part** the posterior region is subdivided into three smaller funiculi by slight furrows. The medial funiculus is close to the posteromedian fissure and is called the *fasciculus gracilis ;* it terminates in the lower part of the fourth ventricle in an expanded elevation called the *clava* beneath which is a nucleus of grey matter called the *nucleus gracilis.* Lateral to the fasciculus gracilis is the *fasciculus cuneatus ;* it also ends in the lower part of the fourth ventricle in an elevation, called the *cuneate tubercle,* which overlies a nucleus of grey matter called the *nucleus cuneatus.* These two fasciculi are the upward continuations of the same strands in the posterior funiculus of the medulla spinalis. Lateral to the fasciculus cuneatus is the *fasciculus of Rolando* which is narrow below and ends above in an elevation, the *tuberculum cinereum.* It is caused by the substantia gelatinosa of Rolando and is covered on the surface by the spinal root of the trigeminal nerve. There is no corresponding part of the fasciculus of Rolando in the posterior funiculus of the medulla spinalis.

At the **upper part** of the medulla oblongata the posterior region is occupied by two thick rope-like strands called the *restiform bodies.* Each restiform body lies between the lower part of the fourth ventricle and the roots of the glossopharyngeal and vagus nerves. It passes upwards and lateralwards diverging from its fellow of the opposite side and forms the lower part of the lateral boundary of the floor of the fourth ventricle ; it then turns backwards and enters the corresponding cerebellar hemisphere ; on account of its forming the connecting link between the medulla spinalis, medulla oblongata and cerebellum it is called the *inferior peduncle of the cerebellum.* The restiform body appears on superficial observation to be formed by the continuation upwards of the fasciculus gracilis and fasciculus cuneatus. But in reality the gracile and cuneate fasciculi terminate in their respective nuclei already referred to.

## Internal Structure of the Medulla Oblongata (Fig. 256)

The internal structure of the medulla oblongata differs strikingly from that of the medulla spinalis. Thus it is seen that some of the fasciculi from the medulla spinalis end in the lower part of the medulla oblongata ; other fasciculi begin in the medulla oblongata and pass into the different parts of the brain ; other fasciculi in their passage from or to the spinal medulla undergo rearrangement and come to occupy different positions in the medulla oblongata and pons. Then again the grey matter instead of being arranged in one continuous column as in the spinal medulla becomes subdivided into a series of nuclei which serve as the deep connections of some of the cerebral nerves ; to these nuclei new masses of grey matter are superadded.

In a transverse section of the medulla oblongata above the level of the pyramidal decussation it is seen to be divided into two lateral halves by a *median raphe* which is formed by the intersection of fibres running in various directions. The medulla oblongata is composed of grey substance and tracts of white substance,

**Grey substance.**—The grey substance of the medulla oblongata is present (1) in the form of direct continuations of the grey substance of the spinal medulla which may or may not have undergone modifications, and (2) in the form of isolated masses or nuclei which are not represented in the spinal medulla. If the anterior grey column of medulla spinalis is traced upwards it is seen on reaching the medulla oblongata to be broken up by the lateral cerebrospinal fasciculus so that the head becomes severed from the base. The base of the anterior grey column remains on the ventral and lateral aspects of the central canal and appears on the floor of the fourth ventricle as a grey mass near the median furrow forming the nucleus of the hypoglossal nerve. The neck of the anterior grey column is replaced by a network of cells and fibres which are partly contributed by the same lateral cerebrospinal fasciculus during its passage and this network constitutes a portion of the formatio reticularis. The head of the anterior grey column is displaced laterally by the pyramid and olive and in the lower part of the medulla it appears as a grey mass called the nucleus lateralis.

If the posterior grey column of the medulla spinalis is traced upwards it is seen, on reaching the medulla oblongata, to be displaced laterally by the fasciculus gracilis and fasciculus cuneatus. Just as the head of the anterior column is broken up by the motor decussation, the head of the posterior column becomes severed from the base by the sensory decussation. The base of the posterior grey column remains on the dorsal and lateral aspects of the central canal and forms in the medulla oblongata the nucleus gracilis and nucleus cuneatus. The neck is replaced by a network of cells and fibres which constitutes a portion of the formatio reticularis. The head appears as a well marked grey mass called the nucleus of Rolando in the middle of the medulla oblongata.

The *nuclei of the medulla oblongata* may be thus arranged: (1) nuclei connected with cerebral nerves, viz. hypoglossal nucleus, nucleus ambiguus, dorsal nucleus, nucleus tractus solitarius, nucleus acusticus; (2) nuclei not connected with cerebral nerves viz., nucleus gracilis, nucleus cuneatus, nucleus arcuatus, and olivary nuclei.

(1) The *hypoglossal nucleus* lies in the lower part of the fourth ventricle, close to the middle line underneath the trigonum hypoglossi; in the closed part of the medulla oblongata it lies anterolateral to the central canal. This nucleus represents the base of the anterior column of grey substance of medulla spinalis. The nucleus is about ¾th inch in length, is composed of groups of multipolar cells and extends from the decussation of the pyramids below to the striæ medullaris above.

(2) The *nucleus ambiguus* or motor nucleus of the glossopharyngeal, vagus and cerebral part of the accessory nerves extends along the whole of the medulla oblongata and lies embedded in the formatio reticularis grisea.

(3) The *dorsal nucleus* of the glossopharyngeal and vagus nerves, lies in the upper part of the medulla oblongata underneath the ala cinerea just lateral to the hypoglossal nucleus; in the lower part of the medulla oblongata it is situated lateral to the central canal and dorsal to the hypoglossal nucleus. Associated with the dorsal nucleus in which the afferent fibres of the glossopharyngeal and vagus partly end is a mass of grey substance, the *nucleus tractus solitarii,* in which also the the afferent fibres of these two nerves partly end.

(4) The *nuclei of the acoustic nerve* will be described in the Section on cerebral nerves.

(5) The *nucleus gracilis* is a collection of nerve cells where the fasciculus gracilis terminates.

(6) The *nucleus cuneatus* is a collection of nerve cells where the fasciculus cuneatus terminates; it is composed of two portions, a large medial nucleus and a smaller lateral nucleus.

(7) the *nucleus arcuatus* lies under cover of the external arcuate fibres at the level of the pyramid.

(8) The *olivary nuclei,* which are associated with the olive are three in number on each side and are named inferior olivary, dorsal accessory olivary, and medial accessory olivary nuclei. The *inferior olivary nucleus* is the principal nucleus and lies underneath the olive. In transverse sections of the olive, it presents the appearance of a wavy lamina of grey substance deficient towards the median line so as to form the *hilum* through which nerve fibres emerge to form the *peduncle of the olive.* The inferior olivary nucleus is connected (*a*) with that of the opposite side by fibres passing through the median raphe; (*b*) with the thalamus by the *thalamo-*

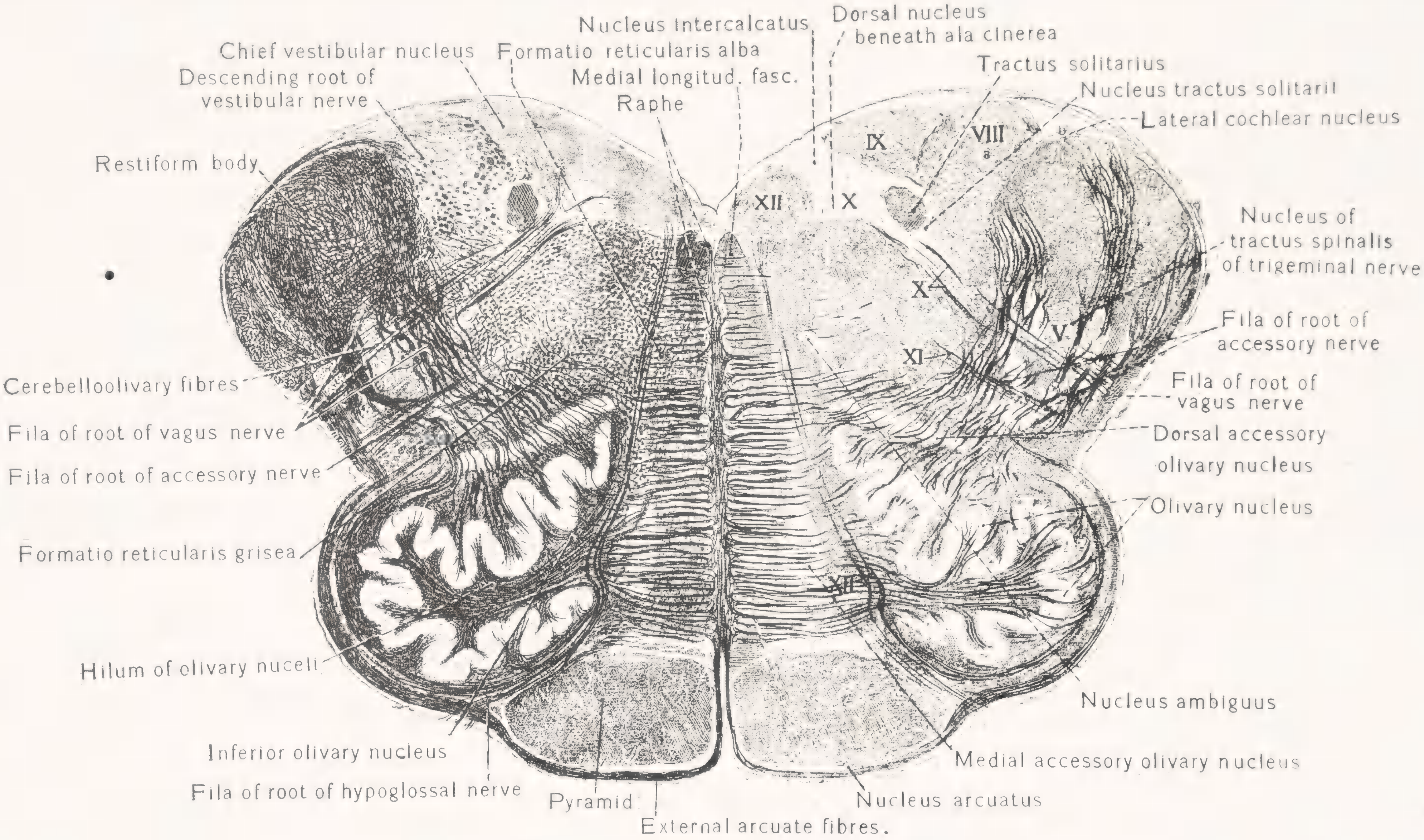
Nucleus intercalcatus
Dorsal nucleus beneath ala cinerea
Chief vestibular nucleus
Formatio reticularis alba
Medial longitud. fasc.
Tractus solitarius
Nucleus tractus solitarii
Descending root of vestibular nerve
Raphe
Lateral cochlear nucleus
Restiform body
IX
VIII
XII
X
Nucleus of tractus spinalis of trigeminal nerve
X
V
XI
Fila of root of accessory nerve
Cerebelloolivary fibres
Fila of root of vagus nerve
Fila of root of vagus nerve
Dorsal accessory olivary nucleus
Fila of root of accessory nerve
Olivary nucleus
Formatio reticularis grisea
XII
Hilum of olivary nuceli
Nucleus ambiguus
Inferior olivary nucleus
Medial accessory olivary nucleus
Fila of root of hypoglossal nerve
Pyramid
Nucleus arcuatus
External arcuate fibres.

Fig. 256.—Transverse section through the medulla oblongata.

To face p. 500.

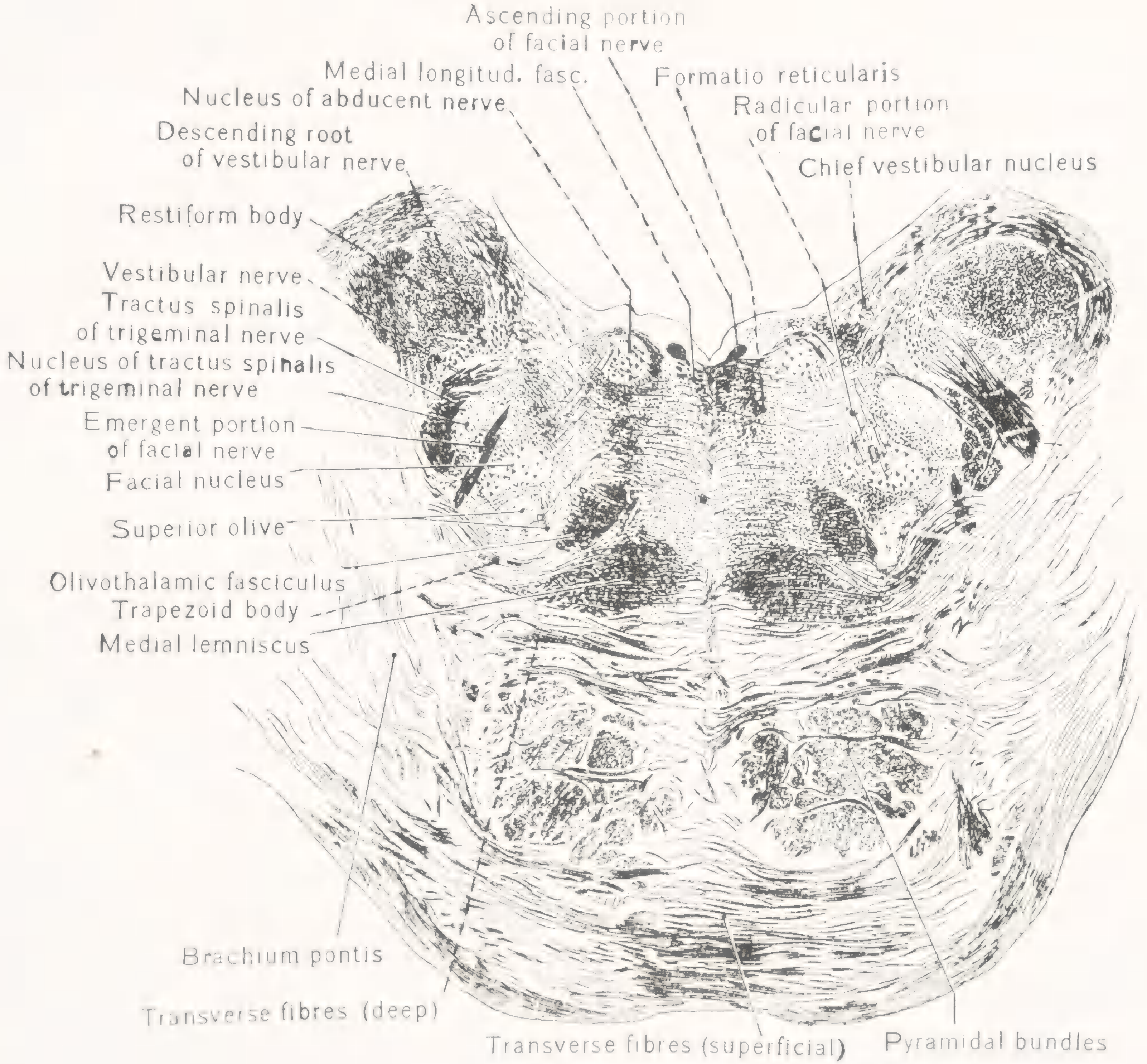

Fig. 257.—Section through the lower part of the pons.

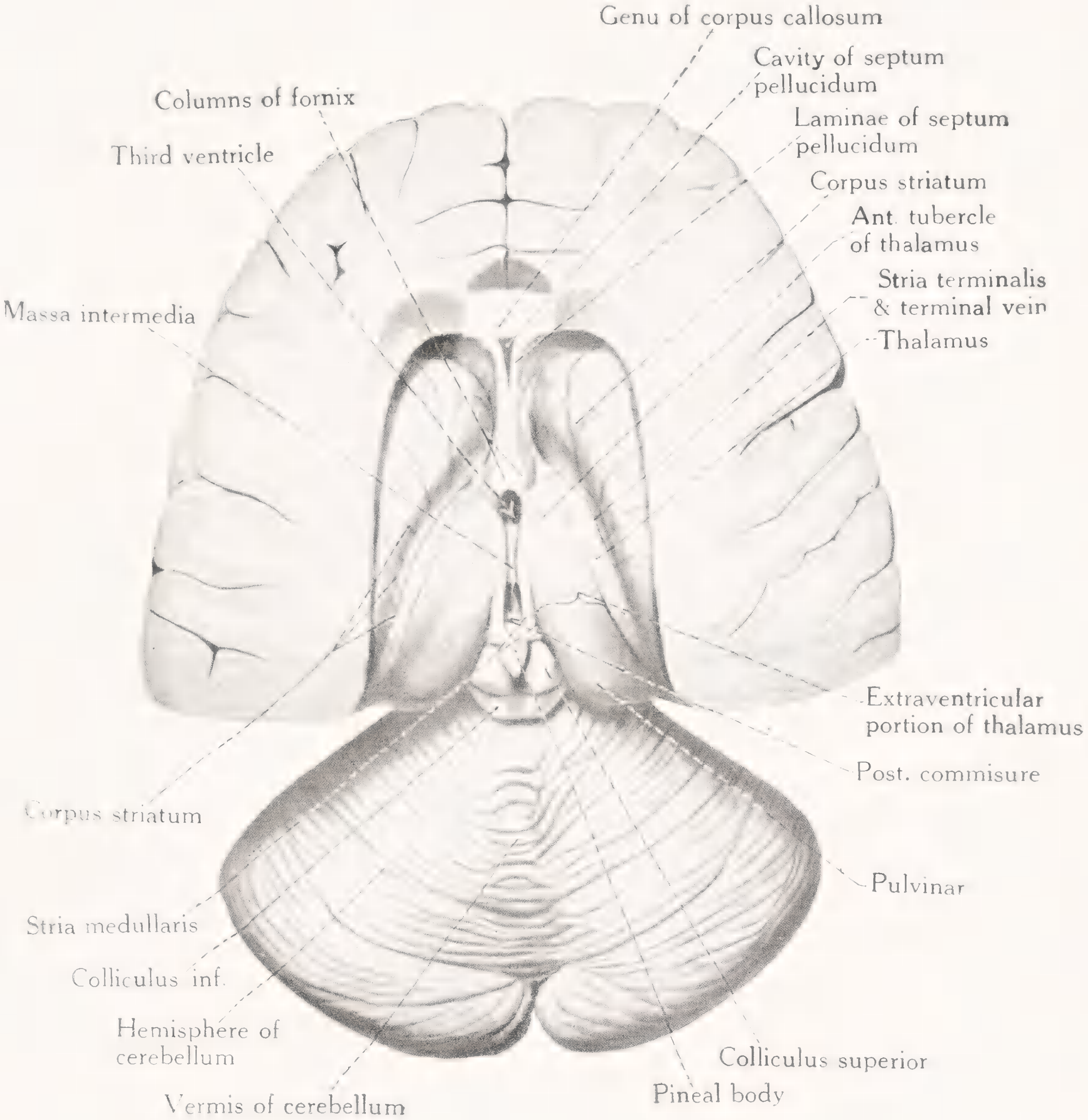

Fig. 261.—The two thalami and the third ventricle exposed from above.

See p. 516.

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To face p. 501.

*olivary fasciculus* which passes through the pons and tegmentum, (*c*) with the opposite side of the cerebellum by the *olivocerebellar fasciculus* which crossing through the median raphe enter the cerebellum through the restiform body, (*d*) with the medulla spinalis of the same side by the *olivospinal fasciculus.* The *medial accessory olivary nucleus* lies medial to the ventral end of the hilum of the inferior olivary nucleus. The *dorsal accessory olivary nucleus* lies dorsal to the hilum of the main nucleus.

The **white substance** of the medulla oblongata is disposed of in tracts or fasciculi which are mainly longitudinal but some run transversely. The principal tracts are :—

(1) **Cerebrospinal fasciculi.**—The downward course of these fasciculi from the pyramids of the medulla oblongata to the medulla spinalis and their partial decussation together with the changes produced in the anterior and posterior columns of grey substance, have been already described.

(2) The **direct cerebellar tract** (posterior spinocerebellar tract) extends upwards from the lateral funiculus of the spinal medulla, traverses the lateral region of the medulla oblongata and passes to the cerebellum ; some of its fibres accompany the lemniscus and reaching the inferior colliculus decussate and reach the cerebellum through the brachium conjunctivum ; most of the fibres however pass backwards and upwards into the restiform body, contribute to the formation of that body and thus reach the cerebellum directly.

(3) The **anterior spinocerebellar tract** extends upwards from the lateral funiculus of the medulla spinalis and comes to lie on the lateral side of the olive ; it is then continued upwards into the pons and it then reaches the cerebellum

(4) The **fasciculi proprii** (basis bundles) assist in the formation of the formatio reticularis of the medulla oblongata ; many of them are collected into a strand called the *medial longitudinal fasciculus*, which runs close to the middle line in the floor of the fourth ventricle in the medulla oblongata and is continuous below with the fasciculi proprii of the anterior and lateral funiculi of the spinal medulla.

(5, 6) **Fasciculus gracilis** and **fasciculus cuneatus.**—The terminations of these two fasciculi in their respective nuclei have already been referred to. From the cells of the gracile and cuneate nuclei new fibres arise ; some of these fibres form the external arcuate fibres and pass lateralwards into the restiform body ; most of them however pass forwards and medially towards the median raphe and are called the internal arcuate fibres.

The **internal arcuate fibres** arise from the nucleus gracilis and nucleus cuneatus. They pass forwards through the neck of the posterior column of grey substance and separate the head from the base. In the middle line the fibres from the two sides decussate and then the fibres ascend as a longitudinal band close to the median plane and separated from each other by the median raphe. This band of fibres is known as the *lemniscus* or *fillet* and is situated just behind the cerebrospinal fibres ; and the decussation of the fibres which is situated above and dorsal to the pyramidal decussation is known as the *decussation of the lemniscus* or *superior sensory decussation.* The head of the posterior column forms the nucleus of the spinal root of the trigeminal nerve ; its base forms the nucleus gracilis and nucleus cuneatus.

The **formatio reticularis** is the name given to the reticulum that is formed in the anterior and lateral regions of the medulla oblongata by the interlacing of longitudinal and transverse fibres. It occupies a position dorsal to the pyramid and olive. It is subdivided into an anterior and a lateral part by the filaments of the root of the hypoglossal nerve. The anterior part is called the *formatio reticularis alba* as it is not intermingled with grey nuclei. The longitudinal fibres in this part are : (1) lemniscus ; (2) tectospinal fibres which come from the superior colliculus ; and (3) the median longitudinal fasciculus which is the continuation upwards of the fasciculus proper of the medulla spinalis. The lateral part of the formatio reticularis is called the *formatio reticularis grisea* for it contains two nuclei of grey substance, viz., *nucleus of Roller* and *nucleus lateralis* and extends laterally to the restiform bodies. The longitudinal fibres in the lateral part are derived mainly from (1) the superficial anterolateral fasciculus of medulla spinalis and (2) the rubrospinal fasciculus. The transverse fibres in both parts of the reticular formation are the external arcuate fibres.

**Structure of the restiform bodies.**—The restiform body is formed chiefly by (1) the fasciculus spinocerebellaris posterior (direct cerebeller tract) which passes upwards from the lateral funiculus of the same side of the medulla spinalis ; (2) the fasciculus olivocerebellaris which connect the inferior olivary nucleus with the opposite side of the cerebellum ; (3) the external arcuate fibres ; (4) fibres from the opposite olivary nucleus ; and (5) fibres uniting the roof nuclei of the cerebellum with the nuclei of origin of the motor cerebral and spinal nerves.

The **external arcuate fibres** arise from the cells of the nucleus gracilis and nucleus cuneatus. They pass forwards and decussate in the middle line forming the transverse fibres of the formatio reticularis. Then they emerge mostly through the anteromedian fissure of the medulla oblongata and curve lateralwards and backwards round the surface of the pyramid and olive and enter the restiform body. Some of the external arcuate fibres emerge between the pyramid and olive to join the main bundle. Where the fibres cover the pyramid, there is a collection of grey matter, called the *nucleus arcuatus,* in which some of the arcuate fibres end and fresh fibres begin. The arcuate fibres connect the nuclei gracilis and cuneatus with the opposite side of the cerebellum. A few fibres connect them with the cerebellum of same side.

**Table of the anterior and posterior columns of grey substance of the medulla spinalis and their counterparts in the medulla oblongata.**

| Medulla spinalis | | Medulla oblongata |
|---|---|---|
| Anterior column.. | Base .. | .. Hypoglosal nucleus. |
| | Neck .. | .. Anterior part of formatio reticularis |
| | Head .. | .. Nucleus lateralis |
| Posterior column.. | Base .. | .. Nucleus gracilis, nucleus cuneatus, nuclei on floor of fourth ventricle. |
| | Neck .. | .. Posterior part of formatio reticularis. |
| | Head .. | .. Nucleus of Rolando |

**Table of the fasciculi of the medulla spinalis and their counterparts in the medulla oblongata.**

| Medulla spinalis | | Medulla oblongata |
|---|---|---|
| Anterior funiculus.. | Fasciculus cerebrospinalis anterior .. | .. from the outer one-third of the pyramid of the same side |
| | Fasciculus proprius anterior | .. Medial longitudinal fasciculus and formatio reticularis |
| Lateral funiculus.. | Fasciculus cerebrospinalis lateralis (crossed) | .. from the inner two-thirds of opposite pyramid |
| | Uncrossed lateral cerebrospinal fibres | .. from outer third cf pyramid of same side |
| | Direct cerebeller tract | .. to restiform body and then to cerebellum |
| | Superficial anterolateral fasciculus<br>Rubrospinal fasciculus<br>Fasciculus proprius lateralis | Lateral area below olive and formatio reticularis |
| | Fasciculus of Lissauer | .. to grey substance of posterior column. |
| Posterior funiculus.. | Fasciculus gracilis | .. to fasciculus gracilis and nucleus gracilis |
| | Fasciculus cuneatus | .. to fasciculus cuneatus and nucleus cuneatus |
| | Fasciculus proprius posterior | .. to or from formatio reticularis |

The **pons** (pons Varolii) (Figs 254, 255) is the connecting link between the cerebrum above, the medulla oblongata below, and the cerebellum behind. At its upper part are seen the cerebral peduncles while its lower part is continuous with the medulla oblongata. Its *ventral* or *anterior surface* is convex and consists of transverse fibres ; these are gathered together on each side into a compact mass, which enters the cerebellum and is termed the *brachium pontis* (middle peduncle of the cerebellum). The trigeminal nerve with its large entering sensory root and its small emerging motor root, is attached to this surface near its upper border and demarcates the brachium pontis which lies lateral to this attachment. This surface rests on the basilar part of the occipital bone and the clivus of the sphenoid and presents a shallow median groove, *sulcus basilaris*, along which the basilar artery passes upwards; on either side of the groove is an elevation caused by the descending cerebrospinal fibres which pass through the substance of the organ. The abducent, facial and acoustic nerves make their superficial appearance in the groove between this surface of the pons and medulla oblongata. The *dorsal* or *posterior surface* forms the upper or pontine part of the floor of the fourth ventricle and is bounded on either side by the brachia conjunctiva.

**Structure of the pons** (Fig. 257).—When transverse sections are made through the pons, it is seen to be composed of a ventral or basilar portion and a dorsal or tegmental portion. The **basilar portion** of the pons is the larger of the two and is composed of (1) transverse fibres, (2) longitudinal fibres and (3) a large amount of grey substance forming the nuclei pontis. The *transverse fibres* of the pons at its lower part is superficial and lies on its ventral aspect; higher up they are situated on its dorsal aspect. These fibres cross at the median plane and are collected together laterally whence they pass on to the cerebellar hemispheres forming the brachium pontis (middle cerebellar peduncles). The *longitudinal fibres* of the pons are derived from the corresponding cerebral peduncle. As they pass downwards on either side of the middle line they produce an elevation on the anterior surface of the pons. A greater part of these fibres are collected together below forming the pyramid of the medulla oblongata of the same side; some of the fibres successively cross towards the opposite side to end around the cells of the motor nuclei of the trigeminal, and facial nerves and in the nuclei of the abducent and hypoglossal nerves; the remaining fibres end in the nuclei pontis of the same side. The *nuclei pontis* occupy the intervals between the longitudinal and transverse fibres of the pons and correspond with the arcuate nuclei of the medulla oblongata.

The **tegmental portion** of the pons may be regarded as the upward continuation of the medulla oblongata, with the exception of the pyramids which are incorporated with the basilar part. It is divided into two symmetrical halves by the median raphe continuous with that of the upper part of the medulla oblongata. It is composed of reticular formation prolonged upwards from that of the medulla oblongata and consists of transverse and longitudinal fibres and of grey nuclei. The *transverse fibres* are collected at the lower part of the pons to form the *trapezoid body*. Within the trapezoid are collections of nerve cells which constitute the *trapezoid nucleus*. The connections of the trapezoid nucleus with the accessory cochlear nucleus will be described with the cochlear nerve. The *longitudinal fibres* present three bundles on each half of the pons; (1) that between the reticular formation and the trapezoid body is the upward prolongation of the *lemniscus*; (2) that near the floor of the fourth ventricle close to the median raphe is the *medial longitudinal fasciculus* ; (3) that which passes to the cerebellum through the brachium conjunctivum is called the *anterior spinocerebellar fasciculus.* In addition to these structures, are nerve cells which are embedded in the formatio reticularis. Besides these nerve cells the clumps of compact grey substance seen in the tegmentum are the nuclei of the trigeminal, abducent, facial and acoustic nerves and the superior olivary nucleus.

(1) The *nuclei of the trigeminal nerve* are two, a sensory and a motor ; the ascending fibres of the sensory root of the trigeminal end in the *upper sensory nucleus* which is situated at the lateral side of the motor nucleus and beneath the brachium conjunctivum ; the descending fibres are however continued down as the *spinal tract of the trigeminal nerve* and end in the *lower sensory nucleus* which is in reality the enlarged upper end of the substantia gelatinosa of Rolando. The *motor nucleus* is on the medial side of the sensory ; it lies near the lateral margin of the fourth ventricle. The motor root of the trigeminal is formed chiefly by fibres emerging from this nucleus and to a small extent by those issuing from a nucleus situated in the grey substance of the floor of the cerebral aqueduct and these latter set of fibres constitute its *mesencephalic root.*

(2) The *nucleus of the abducent nerve* lies on the floor of the fourth ventricle underneath the colliculus facialis above the level of the striæ medullaris. The nerve fibres pass outwards medial to the superior olivary nucleus and make their superficial appearance between the lower border of the pons and the pyramid of the medulla oblongata.

(3) The *nucleus of the facial nerve* is situated deeply in the dorsal part of the lower portion of the pons. The nerve fibres at first pass backwards and medialwards to the floor of the fourth ventricle and reach the posterior end of the nucleus of the abducent nerve and then turning upwards along the medial side of that nucleus they reach the anterior end of the nucleus where they make a sharp bend laterally to emerge at the lower border of the pons in the interval between the olive and the restiform body ; as the bundle passes upwards it produces an elevation, the *colliculus facialis,* on the floor of the fourth ventricle.

(4) The *nuclei of the two divisions of the acoustic nerve* will be fully described with that nerve.

(5) The *superior olivary nucleus* is situated medial to the facial nucleus and close to the lateral part of the trapezoid body just above the inferior olivary nucleus.

## The Cerebellum

The **cerebellum** (Figs. 254, 258, 259) is situated behind the medulla oblongata and the pons and beneath the occipital lobes of the cerebrum. It is covered externally by grey substance which is darker than that of the cerebrum. The white substance occupies its interior. Its surface is not mapped out by tortuous convolutions like those of the cerebrum, but it consists of a large number of thin laminæ which are separated by numerous parallel curved sulci.

The cerebellum consists of two lateral parts called the *hemispheres* and a median part called the *vermis*. The part of the vermis which lies on the upper surface of the cerebellum is called the *superior vermis*; and the part on the lower surface, the *inferior vermis*, which is lodged in a deep median fossa between the hemispheres called the *vallecula cerebelli*. The hemispheres are separated below and behind by a deep notch, called the *posterior cerebellar notch*, into which the falx cerebelli is received. Above and in front they are separated by a broad and shallow notch, called the *anterior cerebellar notch*, which receives the inferior colliculi and brachia conjunctiva cerebelli.

**Superior surface of the cerebellum** (Fig. 258).—The fissures and lobules on the superior vermis are continuous with those on the superior surface of the hemispheres. The fissures have the same names both on the vermis and the hemispheres, but the lobules are differently named. Thus on the superior vermis there are five lobules. Commencing from the front these are: the lingula, the central lobule, the culmen monticuli, the clivus monticuli, and the folium vermis. The lingula has no corresponding lobule on the superior surface of the cerebellar hemisphere. The remaining four lobules of the superior vermis have corresponding lobules on the hemispheres. These are from before backwards; the ala lobulus centralis, the anterior crescentic lobule, the posterior crescentic lobule, and the superior semilunar lobule. The *lingula* consists of four or five folia prolonged upwards from the vermis on to the surface of the anterior medullary velum. The *lobulus centralis* is separated from the lingula by the *pre-*

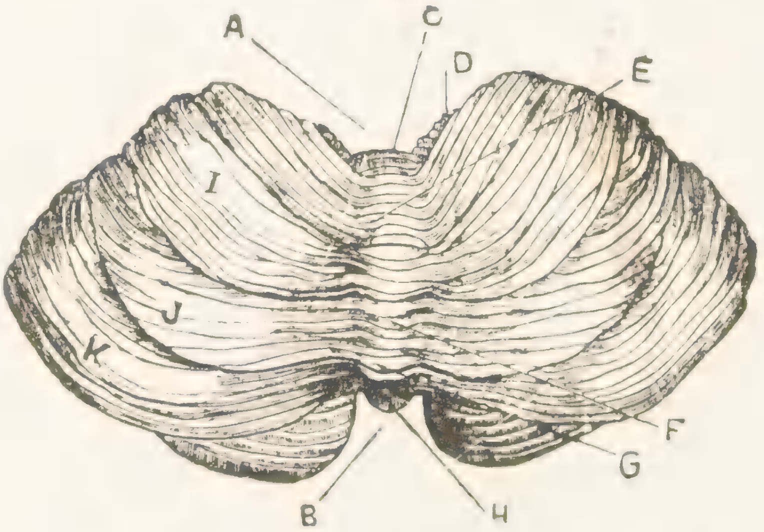


Fig. 258.—Superior surface of the cerebellum.

A. Anterior cerebellar notch.
B. Posterior cerebellar notch.
C. Lobulus centralis.
D. Ala lobuli centralis.
E. Culmen monticuli.
F. Clivus monticuli.
G. Folium vermis.
H. Tuber vermis.
I. Anterior part of quadrangular lobe.
J. Posterior part of quadrangular lobe.
K. Superior semilunar lobule.

*central fissure* and is continuous laterally with the ala lobulus centralis. The *culmen monticuli* is the most prominent part of the superior vermis. It is separated from the lobulus centralis by the *postcentral fissure.* Laterally it is continuous with the anterior cresentic lobule on the hemisphere. The *clivus monticuli* is on the slope of the monticulus and is separated from the culmen by the *preclival fissure* which is prolonged laterally on the hemisphere behind the anterior crescentic lobule. Laterally the clivus is continuous with the posterior crescentic lobule. The culmen and clivus are together called the monticulus. The anterior and posterior cresentic lobules are included under one name, the *quadrangular lobule.* The *folium vermis* (folium cacuminis) is the posterior end of the superior vermis and is separated from the clivus by the postclival fissure. Laterally it is continuous with the superior semilunar lobule on the hemisphere.

The *horizontal sulcus* is the most conspicuous fissure in the cerebellum. It begins in front at the pons, and passing backwards round the lateral and posterior borders of each hemisphere, dips down into the posterior cerebellar notch. It divides the cerebellum into an upper and a lower part demarcating the superior from the inferior surface.

**Inferior surface of the cerebellum** (Fig. 259).—Both the inferior vermis and the inferior surface of the cerebellar hemispheres are subdivided into lobules by fissures. But the continuity of the lobules of the inferior vermis with those on the inferior surface of the hemispheres is not so marked as on the superior surface. The lobules on the inferior vermis from before backwards are: (1) the nodule, (2) the uvula, (3) the pyramid, and (4) the tuber vermis. The lobules on the inferior surface of the hemisphere are: (1) the flocculus, (2) the tonsilla cerebelli, (3) the biventer lobule, and (4) the inferior semilunar lobule. The fissures separating

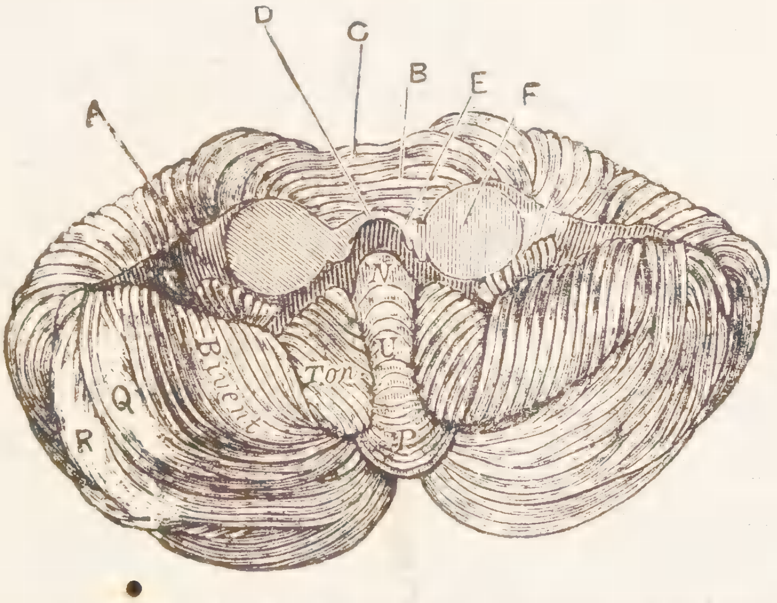


Fig. 259.—Inferior surface of the cerebellum.

A. Flocculus.
B. Ala lobuli centralis.
C. Lobulus centralis.
D. Anterior medullary velum.
E. Brachium conjunctivum.
F. Brachium pontis.

N. Nodule.
P. Pyramid.
Q.
R. } Inferior semilunar lobule.
U. Uvula.

the lobules of the inferior vermis are:—(1) the *postnodular fissure* separates the nodule from the uvula. It passes lateralwards into the hemisphere separating the flocculus in front from the tonsilla and biventral lobule behind and joins the anterior end of the horizontal sulcus. (2) The *prepyramidal fissure* separates the uvula from the pyramid on the inferior vermis; in the hemisphere it curves forwards round the tonsilla between it and the biventral lobe to join the postnodular fissure in front. (3) The *postpyramidal fissure* separates the pyramid from the tuber vermis and passes lateralwards behind the tonsilla and biventral lobule and in front of the inferior semilunar lobule to join the horizontal sulcus. The *nodule* is connected with the flocculus laterally by a thin layer of white substance which emerges from the cerebellum and is called the *posterior medullary velum*. The *flocculus* lies against the brachium pontis. These three parts, viz., the nodule, the posterior medullary velum, and the flocculus constitute the *lobus noduli*. The *uvula* is connected with the tonsilla on either side by a narrow ridge of grey substance marked with furrows on the surface, called the *furrowed band*. The uvula, the furrowed band, and the tonsilla constitute the *lobus uvulae*. The *pyramid* is connected on either side with the biventral lobule by a grey band which lies across the sulcus vallecula. The pyramid, the grey band, and the biventral lobule constitute the *lobus pyramidalis*. The *tuber vermis* is continuous directly with the inferior semilunar lobule; the two lobules are included under one name, the *lobus tuberis*.

**Internal structure of the cerebellum.**—The cerebellum consists of white substance which forms a compact mass in the interior, and of grey substance which is disposed superficially as the cortex.

**White substance.**—When sagittal sections are made through the cerebellum the mass of white substance in the centre is seen to give off offshoots or branches into the lobules. From these branches secondary branches are given off and from these again tertiary branches proceed—in all cases the white substance is covered by grey substance. These radiating white branches from the central mass of white substance present the appearance of a branching tree—this characteristic appearance is called the *arbor vitae cerebelli*. The white substance of the cerebellum includes (1) two sets of nerve fibres viz. the projection fibres, and the fibræ propriæ, and (2) four grey nuclei viz. the nucleus dentatus, nucleus emboliformis, nucleus globosus and nucleus fastigii, which are embedded in the white substance. The *projection fibres* enter or emerge from the white medullary centre and constitute three large bundles, on each side, viz. the brachium conjunctivum, brachium pontis, and restiform body. The *fibrae propriae* include (1) *association fibres* which connect adjacent lobules and laminæ, and (2) *commissural fibres* which connect the opposite halves of the cerebellum.

The *nucleus dentatus* is embedded in the central mass of white substance as a folded lamina of grey substance. Its wall has a wavy outline. Its open mouth or hilum is directed forwards and medialwards through which white fibres of the brachium conjunctivum pass. Its opposite end is blind and is connected by white fibres with the grey substance of the cerebellar cortex. The *nucleus emboliformis* is a small mass and lies medial to the hilum of the nucleus dentatus. The *nucleus globosus* is an elongated mass and lies medial to the nucleus emboliformis. The *nucleus fastigii* or *roof nucleus* is a larger mass and lies close to the median line and contiguous to its fellow of the opposite side. It lies over the roof of the fourth ventricle.

The **grey substance** of the cerebellum is disposed superficially as the cortex and is also found in the central mass of white substance as the four independent nuclei already mentioned. It has also been stated that the grey substance of the cortex covers in each case the primary, secondary and tertiary branches of the central mass of white substance ; thus internally the cortex lies on the white substance and externally is covered by the piamater.

**Minute structure of the grey cortex.**—The grey cortex is composed of two layers, an outer molecular layer and an inner granular layer. Between these two layers is a stratum of large cells called the cells of Purkinje. The *molecular layer* consists of nerve cells and nerve fibres. The *nerve cells* are not very numerous but all possess branched axons : those which are situated in the deeper part are known as the *basket-cells* and are situated in the vicinity of Purkinje's cells ; those which are situated in the superficial part are small. The *fibres* of the molecular layer are derived from : (1) the dendritic processes and axon-collaterals of the cells of Purkinje, (2) dendritic processes of the cells of the molecular layer, (3) the axons of the cells of the granular layer, and (4) the fibres of the white substance of the cerebellum.

The *granular layer* is rust-coloured and consists of (1) granule cells of two kinds viz. granule cells and cells of Golgi and (2) fibres derived from the axons of Purkinje's cells, moss-fibres of Cajal and fibres of the white medullary substance.

The *cells of Purkinje* are arranged in one continuous sheet and constitute the most characteristic structures of the cerebellar cortex. Each consists of a large flask-shaped or piriform cell body, the narrow end of which projects into the molecular layer while the thick end rests against the granular layer. From the thick end a single axon arises which enters the granular layer, where it becomes medullated and then forms a nerve fibre of the white medullary substance. From this axon collateral recurrent branches are given off, some of which end in the molecular layer, others in the granular layer.

**Connections of the cerebellum.**—The cerebellum is connected with the cerebrum, the pons, and the medulla oblongata by three bundles of fibres on each side. These are the brachium conjunctivum, the brachium pontis, and the restiform body.

The **brachium conjunctivum** (superior cerebellar peduncle) emerges from the upper part of the cerebellum and lies medial to the brachium pontis. It forms at first the upper and lateral boundary of the fourth ventricle. Higher up it approaches its fellow of the opposite side and forms the upper part of the roof of the same ventricle. The triangular interval between the two brachia conjunctiva is filled up by the anterior medullary velum. Most of the fibres of the brachium conjunctivum are derived from the dentate nucleus ut a few come from the grey matter of the cerebellar cortex. The fibres of the two brachia pass upwards beneath the corpora quadrigemina and on the ventral aspect of the cerebral aqueduct they decussate. This decussation involves practically all the fibres of the two brachia. The fibres then divide into ascending and descending branches. The ascending braches mostly enter the red nucleus and terminate in arborizations around its cells ; others pass to the thalamus and the nucleus of the oculomotor nerve. The descending branches form a strand, the *descending cerebellar bundle of Cajal,* which traverses the pons and medulla oblongata and is continued into the anterior and lateral funiculi of the spinal medulla. Through the brachia conjunctiva the fibres of (1) the anterior spinocerebellar fasciculus pass to the cerebellum, (2) the tectocerebellar fasciculus pass from the roof of the mesen cephalon to the cerebellum.

The **brachium pontis** (middle cerebellar peduncle) consists of transverse fibres of the pons which being gathered together into a large bundle, enter the cerebellar hemisphere through the anterior part of the horizontal sulcus and lie lateral to the other two peduncles. These transverse fibres contain the axons of the cells of the nuclei pontis and through these fibres the cerebellum gets efferent impulses from the cerebrum. It is the largest of the three peduncles.

The **restiform body** (inferior cerebellar peduncle) enters the cerebellum between the brachium conjunctivum and the brachium pontis. Its formation has been described (p. 502). Before it enters the cerebellum it is crossed dorsally by strands of white fibres called the *striae medullares.*

## The Fourth Ventricle

The **fourth ventricle** (Fig. 255) is situated behind the pons and the upper part of medulla oblongata. It presents for examination two lateral boundaries, four angles, a roof, and a floor.

Each **lateral boundary** is formed below by the clava, the fasciculus cuneatus and the restiform body ; above, by the brachium pontis and the brachium conjunctivum.

**Angles.**—The *superior angle* corresponds to the convergence of the brachia conjunctiva and leads into the cerebral aqueduct. The *inferior angle* corresponds with the lower end of the olive and leads into the central canal of the medulla oblongata. The *lateral angles* correspond with the junctions of the upper lateral and lower lateral boundaries. Below the lateral angle, the fourth ventricle is prolonged laterally, on either side, over the upper part of the restiform body as a recess called the *lateral recess.*

The **roof** or **dorsal wall** of the fourth ventricle is formed above by the brachia conjunctiva and the anterior medullary velum ; below, by the posterior medullary velum, the tela chorioidea of the fourth ventricle lined by ventricular epithelium, the obex, and the tænia of the fourth ventricle. Of these the brachium conjunctivum has been described (p. 509).

The **anterior medullary velum** (valve of Vieussens) is the triangular lamina of white substance which issues from the central white substance of the cerebellum and bridges over the interval between the two brachia conjunctiva. It forms the roof of the fourth ventricle ; on its dorsal surface lies the lingula of the superior vermis while from its substance close to the inferior quadrigeminal bodies, the two trochlear nerves issue.

The **posterior medullary velum** is a thin lamina of white substance which also emerges from the central white substance of the cerebellum in close contact with the anterior medullary velum. The two vela then diverge ; the anterior velum passes upwards and the posterior velum, downwards round the nodule of the inferior vermis. The posterior velum ends below in a thin crescentic margin which is free, but as a matter of fact it is continuous with the ependymal lining of the ventricle.

The *tela chorioidea of the fourth ventricle* is a triangular layer of piamater lined by the ventricular epithelium. It forms the roof of the fourth ventricle below the posterior medullary velum. Above, the tela is continuous with the pia mater on the lower surface of the vermis ; laterally, it is continued over the lateral recess ; below, it is continuous with the pia mater on the restiform body. The *chorioid plexuses of the fourth ventricle* are vascular fringes of the tela chorioidea which project into the ventricular cavity from the roof by pushing the epithelial covering before it. Each plexus presents a vertical and a horizontal limb ; the vertical limb lies close to the middle line ; the horizontal limb passes lateralwards to the end of the lateral recess—it joins its fellow of the opposite side in the middle line. There are three openings in the tela chorioidea by means of which the cavity of the fourth ventricle communicates with the subarachnoidean cavity. One of these, the *apertura medialis* (foramen of Majendii), is situated over the inferior angle of the ventricle. The other two, called the *apertura laterales* (foramina of Key and Retzius), lie over the ends of the lateral recesses.

The *obex* is a thin triangular lamina of grey substance which bridges over the inferior angle of the fourth ventricle from the clava of one side to that of the other.

The *taeniae of the fourth ventricle* (ligulæ) are two narrow bands of white substance seen, one on either side of the lower part of the roof of the fourth ventricle. The medial margin of each tænia is continuous with the epithelial lining of the tela chorioidea ; its lateral margin is attached to the clava and runs transversely across the restiform body below the striæ medullares.

Below it is continuous with the obex. It forms the inferolateral limit of the roof of the fourth ventricle.

The **floor** or **anterior wall** of the fourth ventricle is called the *rhomboid fossa* from its shape. It is lozenge-shaped and is formed by the dorsal surface of the pons above and the dorsal surface of the upper part of the medulla oblongata below. It is bisected by a vertical median groove, called the *median sulcus*; this sulcus extends from the superior to the inferior angle of the fossa and is shallow above but deep below. On eitehr side of this sulcus is an elongated elevation called the *medial eminence* which is limited laterally by a sulcus called the *sulcus limitans*. The rhomboid fossa is traversed at its widest part opposite the lateral recesses by some transverse white fibres, called the *striae medullares* (striæ acusticæ), which belong to the cochlear division of the acoustic nerve. Medially these white strands sink into the median sulcus; laterally they cross the upper part of the restiform bodies. By these striæ the rhomboid fossa is subdivided into an upper and a lower part. In the upper part of the fossa the elevation of the medial eminence occupies the whole width of the corresponding half of the floor of the fossa. Just above the striæ medullares the medial eminence presents a nodular elevation, called the *colliculus facialis*, which is caused by the underlying ascending portion of the root of the facial nerve. In the lower part of the rhomboid fossa and below the colliculus the medial eminence becomes narrow and triangular and is called the *trigonum hypoglossi* as it overlies the nucleus of the hypoglossal nerve. The sulcus limitans presents in its upper part a narrow slate coloured area called the *locus caeruleus*, which owes its colour to pigmented cells, called the *substantia ferruginea*, lying underneath. Lateral to the colliculus facialis the sulcus limitans widens into a shallow fossa called the *superior fovea*; lateral to the trigonum hypoglossi it becomes distinctly deep and is called the *inferior fovea*. Lateral to the superior and inferior foveæ is another triangular elevation called the *area acustica* which extends to the lateral recess and is crossed superficially by the striæ medullares. Below the inferior fovea and between the trigonum hypoglossi and the area acustica is a triangular area darker in colour than the rest of the fovea and called the *ala cinerea* (trigonum vagi). This area corresponds to the sensory nuclei of the glossopharyngeal and vagus nerves. Below the ala cinerea is a ridge-like elevation, called the *funiculus separans*, which separates the ala from a small area on the lower part of the floor called the *area postrema*. The inferior angle of the rhomboid fossa is pointed and from its resenblance to a pen is called the *calamus scriptorius*.

**Isthmus rhombencephali.**—This name is given to the constricted part of the rhombencephalon which lies between the corpora quadrigemina above and the cerebellum below. It is formed laterally by the brachia conjunctiva, dorsally by the anterior medullary velum, and ventrally by the upper part of the pons. It contains the upper part of the fourth ventricle.

## THE MESENCEPHALON OR MID-BRAIN

The **mid-brain** is the short narrow part of the brain which connects the cerebral hemispheres above with the pons and cerebellum below. It is about $\frac{3}{4}$ inch long and it consists of the cerebral peduncles lying ventrally, and four rounded bodies, called the corpora quadrigemina, lying dorsally. The whole of the mid-brain is traversed by a narrow tunnel, called the cerebral aqueduct.

The **cerebral peduncles** (crura cerebri) (Fig. 254) are two thick rope-like bundles which emerge from the upper surface of the pons and diverge from each other to enter the inferior surface of the cerebral hemispheres. Each peduncle presents four surfaces. The ventral surface is crossed in front by the optic tract. The dorsal surface is surmounted by the corpora quadrigemina. The medial surface bounds the interpeduncular fossa and presents a groove, called the *oculomotor sulcus*, from which the oculomotor nerve emerges. The lateral surface presents a groove called the *lateral sulcus* and is crossed in front by the optic tract and behind by the trochlear nerve. The sulci on the medial and lateral surfaces mark the subdivision of each peduncle into a ventral part called the *base* and a dorsal part called the *tegmentum*.

**Structure.**—As seen in transverse section (Fig. 260), the cerebral peduncle consists of a dorsal part called the *tegmentum* and a ventral part called the *base*, separated by a mass of dark pigmented grey substance called the *substantia nigra*.

The **tegmentum** of one side is continuous with that of the opposite side in the median plane. It is composed of grey and white substance. The latter consists of longitudinal as well as transverse fibres. The tegmentum thus forms a reticulated structure which is similar to the reticular formation of the medulla oblongata and the pons of which it is the upward

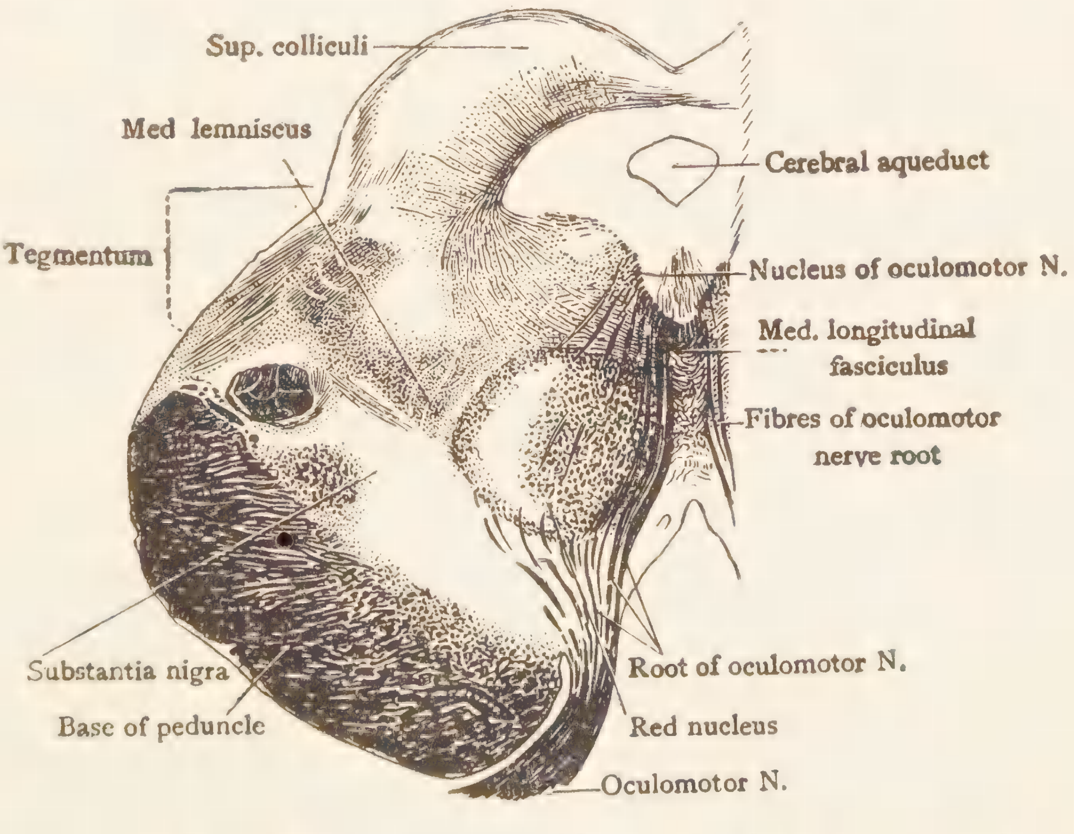


Fig. 260.—Transverse section through the mesencephalon.

prolongation. In the white substance of the tegmentum most of the longitudinal fibres are arranged into well defined tracts, viz., (1) the medial longitudinal fasciculus, (2) the brachium conjunctivum, (3) the lemniscus, (4) the tectospinal fasciculus, and (5) the rubrospinal fasciculus. In the grey substance the chief grey masses are the red nucleus and the interpeduncular ganglion.

The *medial (posterior) longitudinal fasciculus* is a conspicuous tract extending throughout the whole length of the medulla oblongata, pons and mesencephalon. In the medulla oblongata and pons it is placed subjacent to the grey substance of the floor of the fourth ventricle. In the mesencephalon it lies on the floor of the cerebral aqueduct on either side of the middle line. It is a prolongation upwards of the fasciculus proprius anterior and fasciculus proprius lateralis of the medulla spinalis. It extends above as high as a special nucleus called the *nucleus of the medial longitudinal fasciculus*, which is situated in the grey substance of the third ventricle, in front of the opening of the cerebral aqueduct. This fasciculus consists of ascending and descending intersegmental fibres which establish connections between the nuclei of the hind brain and mid brain. It is closely associated with the oculomotor nucleus, the trochlear nucleus and the abducent nucleus; to each of these nuclei it sends its own fibres which end by arborizations around their cells. Some of the fibres of this fasciculus are the axons of cells of (1) the lateral nucleus (Deiters' nucleus) of the vestibular nerve, (2) the sensory nucleus of the trigeminal nerve, (3) the formatio reticularis of the tegmentum, and (4) the formatio reticularis of the pons and medulla oblongata.

The **brachium conjunctivum** (superior cerebellar peduncle) issues from the cerebellum and passes upwards to the inferior colliculus beneath which it disappears. The brachia of the two sides are joined to each other at the lower part by a thin lamina, called the *anterior medullary velum*, with which they form the upper part of the roof of the fourth ventricle. As the brachium passes upwards it approaches its fellow of the opposite side. The fibres of the brachia then proceed taking a deeper course and decussate with each other. The decussated fibres end in the red nucleus and the thalamus.

The **lemniscus** or **fillet** (p. 502) is a tract of longitudinal fibres which passes upwards through the medulla oblongata, pons and mesencephalon. It is divisible into two parts, medial and lateral, which have different origins and terminations. The *medial lemniscus* consists of sensory fibres derived from the nucleus gracilis and nucleus cuneatus of the opposite side in the medulla oblongata; these are joined by fibres derived from the terminal nuclei of the cerebral nerves of the opposite side except those from the cochlear division of the acoustic nerve. The medial lemniscus represents the upward continuation of the gracile and cuneate fasciculi of the spinal medulla and may be called the *chief sensory tract* or the *sensory lemniscus*. Its fibres, traversing the tegmentum end in the thalamus from the cells of which a relay of fibres proceeds to the cerebral cortex; a few fibres, however, pass to the lentiform nucleus and insula.

The *lateral lemniscus* is the upward continuation of the central auditory path and may be called the *acoustic lemmiscus.* Its fibres are derived from the nuclei of the cochlear division of the acoustic nerve and from the trapezoid and superior olivary nuclei, most of the fibres having connections with the opposite side. The fibres having crossed to the opposite side form a definite tract of ascending longitudinal fibres in the dorsal part of the pons and come to lie on the lateral side of the medial lemniscus. In this situation is seen a collection of nerve cells, called the *nucleus of the lateral lemniscus,* Here some of the fibres arborize and fresh fibres originate to continue in the path. They terminate in the inferior colliculus and median geniculate bodies by passing along the lateral aspect of the brachium conjunctivum.

The *tectospinal fasciculus* lies on the ventral aspect of the medial longitudinal fasciculus. Its fibres are derived from the superior colliculus of the opposite side, cross the median plane and decussate with the corresponding fibres of the opposite side—this decussation is known as the *fountain decussation of Meynert.*

The *rubrospinal fasciculus* is derived from the axons of the cells of the red nucleus. Its fibres cross the median plane and decussate with the corresponding fibres of the opposite side—this decussation is known as the *fountain decussation of Forel.* The tectospinal and rubrospinal fasciculi descend through the pons and medulla oblongata into the lateral funiculus of the medulla spinalis.

**Red nucleus.**—If the cerebral peduncle is divided through the superior colliculi a rounded, reddish grey mass is seen. This is the red nucleus. It lies in the upper part of the tegmentum beneath the thalamus. Most of the fibres of the brachium conjunctivum terminate in it. Fibres descend from it to the lateral funiculus of the medulla spinalis of the opposite side as the *rubrospinal tract.* Above it is connected by fibres with the thalamus, corpus striatum, and frontal lobe. The nucleus is traversed by the emerging fibres of the root of the oculomotor nerve.

The *interpeduncular ganglion* is a small nucleus of grey substance in the ventral part of the tegmentum which is connected above with the habenular ganglion by a band of fibres called the *fasciculus retroflexus of Meynert.*

The **substantia nigra** presents a crescentic outline on transverse section; it is a mass of deeply pigmented grey substance lying between the tegmentum and the base of the cerebral peduncle. It extends from the upper part of the pons to the subthalamic region. Its dorsal surface is concave and ventral surface convex. From the ventral surface processes project into the substance of the base of the peduncle. Its medial end is thick and lies against the occulomotor sulcus. Its lateral end lies against the lateral sulcus.

The **base of the peduncle** (crusta or pes) is semilunar on transverse section and is made up of longitudinal bundles of white fibres. These bundles may be divided into three main parts. (1) The fibres, occupying the lateral fifth of the base and called the *temporopontine fibres*, begin from the temporal lobe of the hemisphere and end in the pons. (2) The fibres, occupying the middle three-fifths of the base and called the *cerebrospinal fibres*, begin from the motor area of the cerebral cortex and proceed through the pons and the medulla oblongata, where some of the fibres end around the motor nuclei of the cerebral nerves. But most of the fibres are continued to the medulla spinalis. (3) The fibres occupying the medial fifth of the base, called the *frontopontine fibres*, begin from the frontal lobe and end in the pons.

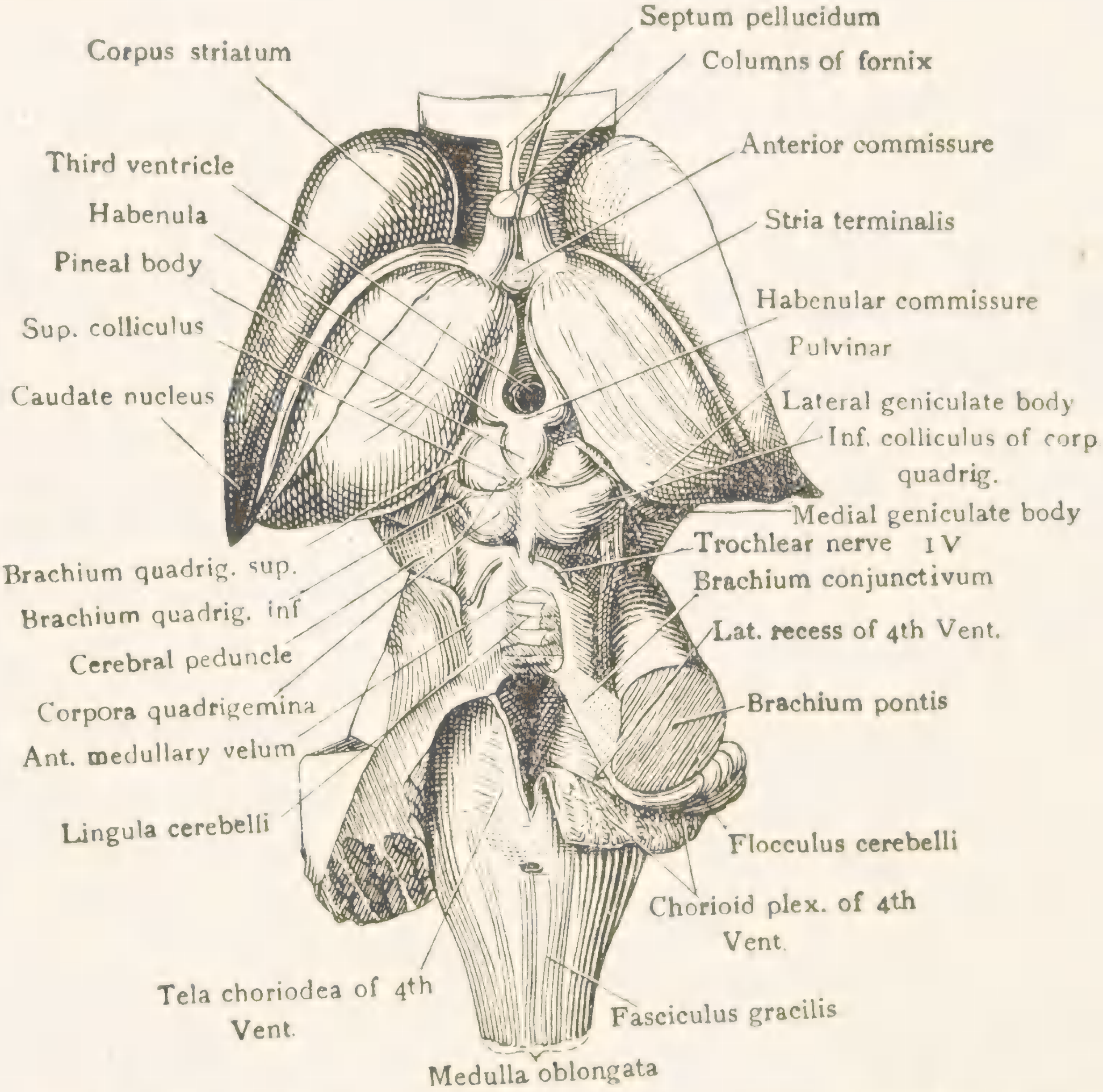


Fig. 262.—The medulla oblongata, mesencephalon and thalamencephalon.

The **corpora quadrigemina** (Figs. 255, 261, 262), are two pairs of rounded eminences composed of grey substance with a coating of white substance on the surface. They are situated on the dorsal aspect of the mid-brain. The upper pair, called the *superior colliculi*, are oval in shape and larger than the lower pair, called the *inferior colliculi*, which are rounded. A cruciate groove separates the four eminences from each other. The longitudinal limb of the cruciate groove lies along the median line and ends above in a depression in which the pineal body lies. The lower end of the longitudinal limb terminates in a narrow white band, called the *frenulum veli*, which is continuous with a lamina called the anterior medullary velum. This lamina forms the upper part of the roof of the fourth ventricle. From each colliculus a white band, the *brachium*, passes upwards and forwards towards the geniculate body. The *superior brachium* passes upwards, forwards and lateralwards between the medial geniculate body and the pulvinar and divides into two parts ; one of which enters the lateral geniculate body and the other is continuous with the optic tract. The *inferior brachium* passes upwards and forwards and ends beneath the medial geniculate body.

**Structure** of corpora quadrigemina.—The *inferior colliculus* is composed mainly of a mass of grey substance. This central nucleus consists of large and small multipolar nerve cells and the whole mass is pervaded by fibres derived mainly from the lateral lemniscus. Most of these fibres terminate in arborizations around the cells of the central nucleus ; others pass over its dorsal surface so as to form a thin dorsal layer ; others pass over its ventral surface so as to form a thin ventral layer ; while several fibres end in the central nucleus of the same side. Some fibres, however, cross the middle line and end in that of the opposite side on account of the intimate connection of the fibres of the lateral lemniscus with the nucleus of the inferior colliculus and as the former is mainly derived from the nuclei of termination of the cochlear nerve, the inferior colliculus becomes intimately connected with the organ of hearing.

The *superior colliculus* is coated superficially with a thin layer of white substance called the *stratum zonale*, the fibres of which are derived mostly from the optic tract. Underneath this is a crescentic layer of grey substance containing many nerve cells and is called the *stratum griseum*. The third layer is formed by the *stratum opticum* which is composed of grey subtance and contains numerous nerve cells and nerve fibres. The *stratum lemnisci* is the deepest layer and is also composed of grey substance traversed by fibres. These fibres are derived from the lemniscus and from the cells of the stratum opticum. Nerve fibres reach the superior colliculus(1) through the lemniscus, —these fibres from the lemniscus constitute the stratum lemnisci ; and (2) through the superior brachium—some of these fibres of the superior brachium contain fibres of the optic tract and are thus connected with the retina ; others contain fibres from the occipital lobe and are thus connected with the visual centre in the occipital region of the cerebral cortex.

The **cerebral aqueduct** (aqueduct of Sylvius) is a narrow canal, about half an inch in length, leading from the fourth to the third ventricle. It is placed nearer the dorsal than the ventral surface of the mid-brain. On transverse section the appearance of the aqueduct varies at different levels of the mid-brain. Thus at the upper part it is triangular ; in the middle part it is oval and in the lower part it is T-shaped. It is surrounded by a layer of grey substance called the *central grey stratum* which contains numerous nerve cells disposed in a scattered manner and three definite collections of nerve cells which constitute the nuclei of origin of the oculomotor nerve, the trochlear nerve, and the mesencephalic root of the trigeminal nerve. The *nucleus of the oculomotor nerve* is placed in the ventral part of the central grey stratum beneath the superior colliculus. It is about 5 mm. long and extends above into the grey substance of the lateral wall of the third ventricle ; below it is continuous with the nucleus of the trochlear nerve. The *nucleus of the trochlear nerve* is a small oval mass, situated in the ventral part of the central grey stratum at the level of the upper part of the inferior colliculus. The *nucleus of the mesencephalic root of the trigeminal nerve* is situated in the lateral part of the central grey stratum.

## THE PROSENCEPHALON OR FORE-BRAIN

The prosencephalon or forebrain is subdivided into two parts : the posterior part is called the diencephalon while the anterior part is called the telencephalon.

### The Diencephalon

The **diencephalon** comprises : (1) the thalamus, (2) the epithalamus, (3) the metathalamus, and (4) the hypothalamus. Superiorly and in front it is connected with the central hemispheres ; inferiorly it reaches up to the base of the brain ; posteriorly it becomes connected with the mesencephalon. Strictly speaking the anterior part of the third ventricle and the optic part of the hypothalamus belong to the telencephalon and not to the diencephalon, but it is convenient to describe the whole of the third ventricle and the hypophalamus with the diencephalon.

The **thalamus** (optic thalamus) (Figs. 261, 262), is a large oval-shaped mass of grey substance coated on its superior surface by a thin layer of white substance called the *stratum zonale*. The thalami are two in number situated one on either side of the third ventricle. Each thalamus presents four surfaces and two ends. The *superior surface* is convex and is bounded laterally by the oblique groove which separates it from the caudate nucleus. This groove contains a slender band of longitudinal fibres, called the *stria terminalis,* and in the forepart of the groove lies the terminal vein. Medially this surface is bounded in its anterior half by a linear elevation called the *taenia thalami*—from the tænia the ependyma of the third ventricle is reflected to the under surface of the tela chorioidea. Behind the portion of the tænia thalami which proceeds medialwards to the pineal body is a small triangular area called the *trigonum habenulae*. The superior surface is subdivided by an oblique groove, which corresponds to the lateral margin of the body of the fornix, into a lateral and a medial portion. The lateral portion forms the floor of the central part of the lateral ventricle. The medial portion is covered by the tela choriodea of the third ventricle. The *inferior surface* rests upon the dorsal part of the cerebral peduncle. The *medial surface* forms the lateral wall of the third ventricle and is connected with the medial surface of the opposite thalamus by a soft mass of grey substance called the *massa intermedia* (middle commissure). The *lateral surface* lies against a band of white substance called the internal capsule. The *anterior end* points forwards and medialwards. It approaches its fellow of the opposite side and presents an elevation called the *anterior tubercle* which forms the posterior boundary of the interventricular foramen. The *posterior end* projects backwards and lateralwards. It diverges from its fellow of the opposite side and ends in a tubercle called the *pulvinar*. Beneath the pulvinar is a small pea-like oval swelling called the *medial geniculate body* which is connected with the inferior colliculus by the inferior brachium. Below and lateral to the pulvinar is another oval swelling called the *lateral geniculate body* which is connected with the superior colliculus by the superior brachium.

**Structure.**—The thalamus is composed chiefly of grey substance. Its superior surface is covered with a layer of white substance called the *stratum zonale* and its lateral surface is covered with a reticular layer of white substance called the *lateral medullary lamina*. The grey substance of the thalamus is subdivided into three nuclei by another white lamina called the *medial medullary lamina*. This lamina consists of a single stem behind and bifurcates in front thus subdividing the substance of the thalamus into three nuclei. The *anterior nucleus* is embraced by the bifurcating limbs of the medial lamina and includes the anterior tubercle and in it the mamillo-thalamic fasciculus ends. The *medial nucleus* is small and lies against the lateral wall of the third ventricle. The *lateral nucleus* is the largest and includes the posterior end of the thalamus. The stem of the medial lamina separates the medial from the lateral nucleus.

**Connections of the thalamus.**—The thalamus may be regarded as a ganglionic mass or an aggregation of cell stations in which the ascending tracts of the tegmentum and a large number of fibres of the optic tract terminate. From the axons of the cells of the thalamus there arise innumerable fibres, the *thalamocortical fibres* which pass to every part of the cerebral cortex to form what is known as the *thalamic radiation*. These fibres are conveniently arranged in four groups or stalks. They are (1) the anterior or *frontal stalk* which passes through the frontal part of the internal capsule to the cortex of the lobe ; (2) the *parietal stalk* which passes from the lateral surface of the thalamus to the parietal lobe ; (3) the inferior or *temporal stalk* which passes from the medial and inferior surface of the thalamus beneath the lentiform nucleus to the temporal lobe and insula ; (4) the posterior or *occipital stalk* (optic radiation) which passes from the posterior end of the thalamus through the occipital part of the internal capsule to the occipital lobe.

The **epithalamus** consists of (1) the pineal body, (2) the trigonum habenulæ, and (3) the posterior commissure.

The **pineal body** (Figs. 261, 262), is a small conical, reddish body which is placed beneath the splenium of the corpus callosum and lies in the depression between the upper pair of corpora quadrigemina. It is covered by a fold of pia mater derived from the inferior layer of the tela chorioidea of the third ventricle. Its apex is directed backwards and its base which looks forwards is fixed by means of a stalk or peduncle. The *stalk* divides into a ventral and a dorsal part. The ventral part becomes continuous with a transverse band of white fibres lying underneath the pineal body called the posterior commissure. The dorsal part divides into two medullary striæ, each of which is prolonged on the thalamus of the corresponding side to be continuous with the tænia thalami. Between the ventral and dorsal parts of the stalk is a recess called the *pineal recess.*

**Structure.**—The pineal body is not composed of nervous constituents. The only nerves found in it are some sympathetic filaments. It consists of a number of follicles filled with epithelial cells and containing a variable amount of calcareous matter composed chiefly of calcium, ammonium and magnesium phosphates.

The **trigonum habenulæ** is a triangular depression lying lateral to the posterior part of the pineal stalk and in front of the superior colliculus of the corpora quadrigemina. It contains a collection of nerve-cells called the *ganglion habenulae.* Some fibres from this ganglion pass to the ganglion of the opposite side along the roof of the third ventricle. These fibres form what is called the *habenular commissure.*

The **posterior commissure** is a transverse band of white fibres which stretches across the upper end of the cerebral aqueduct. It lies behind the third ventricle and the pineal body lies over it. It is connected on either side with a nucleus in the central grey substance of the cerebral aqueduct, called the *nucleus of the posterior commissure.*

The **metathalamus** consists of the two geniculate bodies, a medial and a lateral, on each side.

The **medial geniculate body** contains many nerve cells ; the axons of these cells become fibres which proceed to the temporal lobe of the cerebral cortex. It receives acoustic fibres from the lateral lemniscus and is thus associated with hearing.

The **lateral geniculate body** is composed of a series of alternately placed curved lamellæ. The white lamellæ is composed of fibres which belong to the optic tract. The axons of the cells of the grey substance enter the optic radiation and pass to the visual area in the occipital lobe of the cerebral cortex—the lateral geniculate body is thus associated with sight.

The **hypothalamic region** or **subthalamic tegmental region** is the name given to that part of the tegmentum which is prolonged upwards and lies below the posterior part of the thalamus.

In sections through this region the parts noted are the upward prolongations of the red nucleus and substantia nigra of the tegmentum ; the medial lemniscus ; the fibres of the brachium conjunctivum ; and the corpus subthalamicum. The red nucleus and the substantia nigra disappear at the level of the corpus mamillare. The medial lemniscus lies on the lateral and dorsal aspects of the red nucleus. The fibres of the brachium conjunctivum mostly end in connection with the cells of the red nucleus. The *corpus subthalamicum* or *nucleus of Luys* is a lenticular mass of grey substance, surrounded by white fibres and lies on the lateral side of the substantia nigra.

The **hypothalamus** consists of two parts : (I) the *pars mamillaris hypothalami* which comprises the corpora mamillaria and the small grey substance lying in its immediate vicinity on the floor of the third ventricle ; (II) the *pars optica hypothalami* which comprises (1) tuber cinereum, (2) infundibulum, (3) hypophysis, (4) optic commissure, and (5) lamina terminalis.

The **corpora mamillaria** (Fig. 254) are two small, white pea-like bodies placed side by side in the interpeduncular fossa in front of the posterior perforated substance. Each consists of white substance externally and grey substance internally. The strands of fibres connected with each corpus mamillare are : (1) a bundle of fibres, the *mamillothalamic fasciculus* or *bundle of Vicq d' Azyr* arises from the axons of the cells of the grey substance and extends into the thalamus, terminating in connection with the cells of the anterior nucleus of that body ; (2) the *peduncle of the corpus mamillare* also arises from the axons of the cells of of the grey substance and passes downwards and backwards in grey substance of the floor of the third ventricle to reach the tegmentum of the mesencephalon ; (3) the column of the fornix passes downwards to terminate in the cells of the corpus.

The **tuber cinereum** (Fig. 254) is a slight eminence of grey substance placed immediately behind the optic chiasma and between the optic tracts.

The **Infundibulum** (Fig. 254) is a hollow conical process which projects downwards from the tuber cinereum and becomes attached to the posterior lobe of the hypophysis.

The **hypophysis** (pituitary body) is an oval reddish grey mass which is lodged in the fossa hypophyseos of the sphenoidal bone where it is retained by the diaphragma sellæ. Its long axis is transverse and is somewhat flattened from above downwards. It consists of a larger anterior and a smaller posterior lobe. The *anterior lobe* is developed as a pouch from the buccal cavity of the embryo and presents a concavity behind where the posterior lobe is received. The anterior lobe is subdivided by a narrow cleft into an anterior part, *pars anterior*, and an intermediate part, *pars intermedia*. The *posterior lobe* is developed from the brain and is connected with the tuber cinereum by the infundibulum.

The **lamina terminalis** is a thin layer of grey substance which extends upwards from the upper surface of the optic chiasma and becomes continuous with the genu of the corpus callosum.

The **optic chiasma** (Fig. 254) is a short commissural band which connects the two optic tracts. It lies above the tuberculum sellæ—the lamina terminalis lies above it, the tuber cinereum behind it, and the internal carotid artery lateral to it. It receives the optic nerves at its anterolateral angles and from its posterolateral angles the optic tracts issue. The fibres of the optic chiasma arise mostly from the retinæ which pass through the optic nerves to reach the chiasma. In the chiasma the fibres from the medial half of the retina cross the middle line and pass to the optic tract of the opposite side; the fibres from the lateral half of the retina do not cross but pass to the optic tract of the same side, the posterior part of the chiasma does not contain fibres of the optic nerve but forms a band of fibres, the *commissure of Gudden*, which connects the medial geniculate body of one side to that of the opposite side.

**Optic tracts.**—Each tract is a flattened band of nerve fibres which passes backwards from the posterolateral angle of the optic chiasma. It proceeds between the tuber cinereum and anterior perforated substance, winds round the cerebral peduncle, and divides into a medial and a lateral root. The *medial* or *commissural root* is the smaller of the two and as already stated its fibres have no connection with the optic nerve. These fibres pass to the medial geniculate body and having traversed the medial part of the optic tract, they cross the back part of the commissure and become continuous with the corresponding fibres of the opposite side—constituting what has already been described as the commissure of Gudden. The *lateral* or *visual root* consists of (1) afferent fibres derived (*a*) from the lateral half of the retina of the same side, and (*b*) from the medial half of the retina of the opposite side—these latter cross in the optic commissure; and (2) of efferent fibres which pass from the cerebral cortex to the retina. The afferent fibres have a three fold destination—they terminate by arborizing around the cells of the lateral geniculate body, pulvinar of the thalamus and superior colliculus and these bodies constitute the terminal nuclei or *lower visual centres* of the lateral root. The *higher visual centre* is placed in the cortex of the occipital lobe of the cerebrum and the connections between the higher centre and the lower centre are established by a strand of fibres which constitutes the *optic radiation*. The fibres of the optic radiation are afferent or corticipetal and efferent or corticifugal. The afferent fibres arise as the axons of the cells in the lateral geniculate body and the pulvinar, around which the retinal fibres terminate and end in the cortex of the occipital lobe. The efferent fibres arise as the axons of the cells of the visual area of the occipital lobe and end in the pulvinar and superior quadrigeminal body. Thus the optic radiation forms a conspicuous strand which passes through the post-lenticular part of the internal capsule and then backwards into the medullary substance of the occipital lobe lying on the lateral side of the posterior cornu of the lateral ventricle. Thereafter the fibres proceed in a radiating manner to reach the higher visual centre.

## The Third Ventricle

The **third ventricle** (Figs. 261, 262) is the deep, narrow interval between the two thalami and reaches down to the base of the brain. It presents a roof, a floor, an anterior and a posterior boundary, and two lateral walls. Its *roof* is formed by a thin epithelial layer which stretches from one tænia thalami to the other and is continuous with the ependymal lining of the ventricle. Applied to the superficial surface of this epithelial roof is a fold of piamater called the *tela choriodea,* from the under surface of which the two chorioid plexuses of the third ventricle project downwards one on either side of the middle line—each invaginating the epithelial roof. Its *floor* is formed by certain parts found in the interpeduncular fossa at the base of the brain, viz., the tuber cinereum with the infundibulum, the corpora mamillaria, and the posterior perforated substance. Besides these structures the floor is formed more posteriorly by the tegmenta of the cerebral peduncles. The *anterior boundary* is formed by the lamina terminalis, the columns of the fornix and the anterior commissure. The *posterior boundary* is formed by the posterior commissure, the pineal body and the cerebral aqueduct. The *lateral wall* is formed above by the medial surface of the thalamus, and below, by a lamina of grey matter which passes upwards from the floor of the ventricle. The third ventricle communicates in front with the lateral ventricles through the interventricular foramina and behind with the fourth ventricle through the cerebral aqueduct, the opening of which is seen just beneath the posterior commissure. A shallow groove, called the *hypothalamic sulcus,* extends along the lateral wall from the interventricular foramen to the opening of the cerebral aqueduct and indicates the lower limit of the medial surface of the thalamus. The ventricular cavity is crossed about its middle by the massa intermedia.

**Recesses of the third ventricle.**—Five reeesses or small diverticula are seen in the third ventricle. In the anterior wall these are : the *optic recess* which lies above the optic chiasma and is situated at the junction of the anterior wall with the floor of the ventricle ; and the *vulva* which lies above the anterior commissure. In the floor a funnel-shaped recess, called the *recessus infundibuli* is seen to project into the infundibulum. In the posterior wall there are **two** recesses : the *pineal recess* which passes into the stalk of the pineal body above the posterior commissure ; and the *suprapineal recess* which lies above the pineal body—the wall of this diverticulum is formed by a prolongation of the epithelium of the roof of the ventricle.

## The Telencephalon

The **telencephalon** comprises (1) the two cerebral hemispheres and their cavities called the lateral ventricles ; (2) the anterior part of the third ventricle; and (3) the optic part of the hypothalamus.

## The Cerebral Hemispheres

The cerebral hemispheres are right and left and form by far the largest part of the brain. Each hemisphere is a semiovoid mass and is incompletely separated from its fellow of the opposite side by a median cleft called the *longitudinal cerebral fissure*. The surfaces of the hemispheres are mapped out by eminences called *convolutions* or *gyri* separated from each other by furrows called *fissures* or *sulci*. The arrangement of the gyri and the sulci vary not only in different brains but also in the two hemispheres of the same brain. Their general arrangement, however, is sufficiently constant.

Each hemisphere presents three **surfaces**, four **borders** and three **poles**. The *lateral surface* (Fig. 263), is convex and fits into the concavity of the vault of the cranium. The *medial surface* (Fig. 264), is flat and is separated from that of the opposite hemisphere by the falx cerebri. The *inferior surface* (Fig. 265), is irregular and may be subdivided into three portions corresponding to their situation. Thus the anterior portion is formed by the inferior or orbital surface of the frontal lobe. It is concave and lies on the roof of the orbit. The middle portion is formed by the inferior surface of the temporal lobe. It is convex and lies in the middle cranial fossa. The posterior portion is formed by the inferior or tentorial surface of the occipital lobe. It is concave and lies on the tentorium cerebelli. The borders separating these surfaces from each other are:—(1) The *superomedial border* which separates the lateral from the medial surface. (2) The *inferolateral border* which separates the lateral from the inferior surface; the front part of this border separating the lateral from the orbital surface is called the *superciliary border*. About two inches in front of the posterior end of the hemisphere there is a notch in the inferolateral border called the *preoccipital notch*. (3) The *medial orbital border* separates the medial surface from the orbital part of the inferior surface. (4) The *medial occipital border* separates the medial surface from the tentorial part of the inferior surface of the occipital lobe. The anterior end of each hemisphere is called the *frontal pole* and the posterior end, the *occipital pole*. The anterior end of the temporal lobe is called the *temporal pole*. Structurally the cerebral hemispheres are composed of an outer layer of grey substance or *cortex* and an inner layer of white or *medullary substance*. In addition there are certain collections of grey substance towards the base of each hemisphere called the *basal ganglia*.

The **longitudinal cerebral fissure** is the antero-posterior cleft in the medial plane between the two cerebral hemispheres. In front and behind it completely separates the two hemispheres, but in its middle portion, the great transverse commissural band, the corpus callosum, forms its floor and connects the hemispheres together. The falx cerebri projects into it.

The fissures on the cerebral hemispheres are of two kinds, complete and incomplete. The *complete fissures* are produced by infoldings of the whole thickness of the brain wall producing corresponding elevations in the brain cavity. Portions of the chorioidal, calcarine and collateral fissures are complete fissures. The *incomplete fissures* cause indentations on the cortical grey substance and the subjacent white substance without producing elevations in the brain cavity. The fissures are also classified into interlobar and intralobar; the former demarcate the different lobes from each other; the latter demarcate the different gyri in a particular lobe.

The **interlobar fissures** are eight in number; on the lateral surface of each cerebral hemisphere are: (1) the lateral fissure, (2) the central sulcus, (3) the parieto-occipital fissure, and (4) the circular sulcus; on the medial surface of each hemisphere are: (5) the cingulate sulcus, (6) the calcarine fissure, and (7) the sub-parietal sulcus; on the tentorial surface of each hemisphere is (8) the collateral fissure. The parietooccipital fissure occupies both the medial and lateral surfaces.

The **lateral cerebral fissure** (fissure of Sylvius) (Fig. 263) begins at the inferior surface of the hemisphere and terminates on its lateral surface. It consists of a stem and three rami. The *stem* begins at the anterior perforated substance and passes lateralwards between the orbital surface of the frontal lobe and the anterior end of the temporal lobe. Reaching the lateral surface of the hemisphere it divides into three rami, the anterior horizontal, the anterior ascending, and the posterior. The *anterior horizontal ramus* passes horizontally forwards for about an inch into the

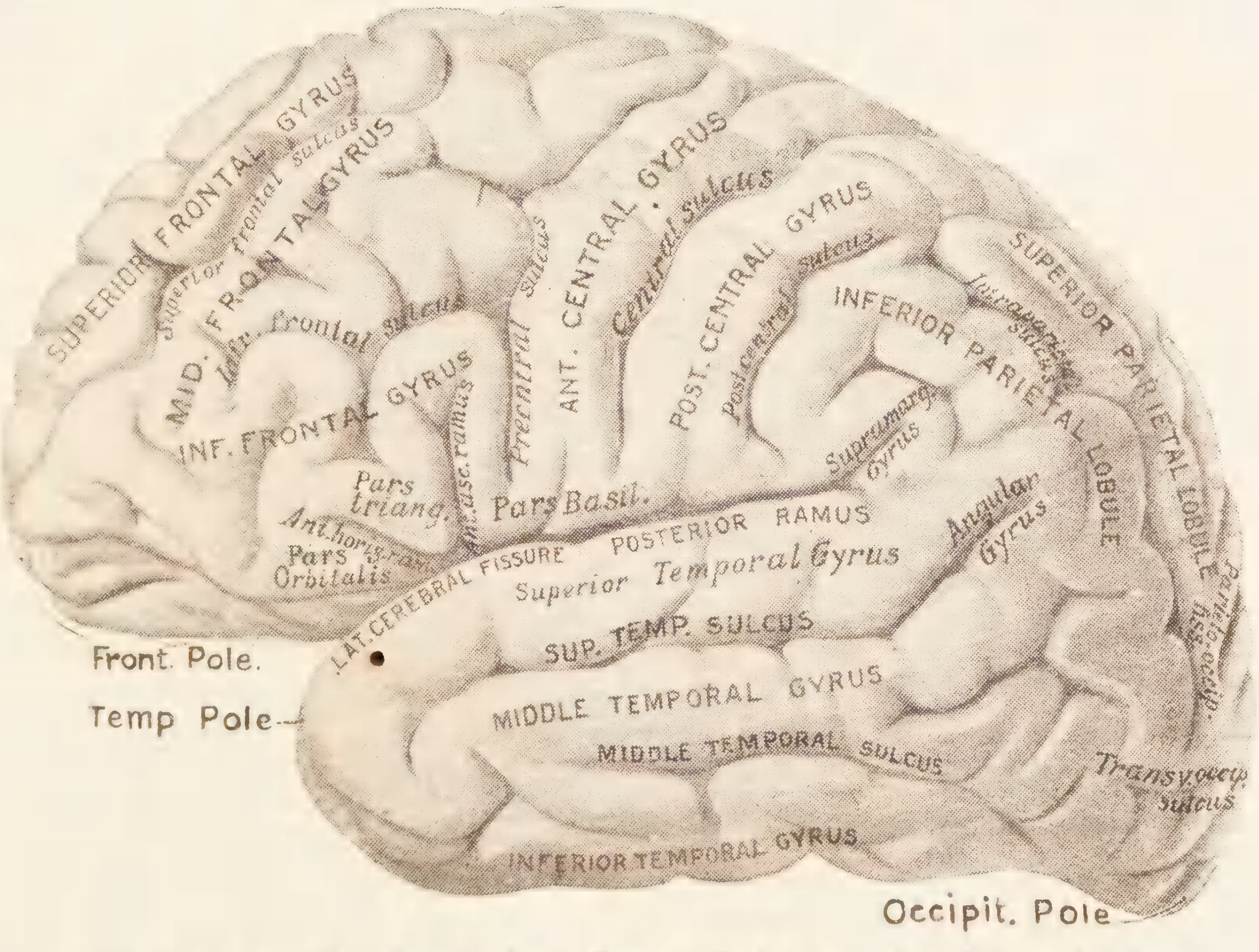


Fig. 263.—The lateral surface of the cerebral hemisphere.

lower part of the lateral surface of the frontal lobe. The *anterior ascending ramus* ascends almost vertically into the lower part of the lateral surface of the frontal lobe for about an inch. The *posterior ramus* is the continuation backwards and upwards of the stem. It is about 3 inches in length and lies between the frontal and parietal lobes above and the temporal lobe below. Its terminal portion is bent upwards into the lower part of the parietal lobe.

The **central sulcus** (fissure of Rolando) commences at or near the longitudinal fissure a little behind its middle and runs obliquely downwards and forwards along the lateral surface of the cerebral hemisphere to terminate a little above the posterior ramus of the lateral fissure at the junction of its anterior and middle thirds. In its course it presents two bends: the upper bend is called the *superior genu* and has its concavity directed forwards; the lower bend is called the *inferior genu* and has its concavity directed backwards. This fissure separates the frontal lobe from the parietal lobe on the lateral surface.

**Parietooccipital fissure.**—A small portion of it is seen on the lateral surface of the cerebral hemisphere and is called the lateral part; the greater portion of it is situated on the medial surface and is called the medial part. The *lateral part* passes lateralwards for about half an inch from the longitudinal fissure and is situated about one inch and a half to two inches in front of the occipital pole. The *medial part* passes downwards and forwards on the medial surface of the hemisphere and meets the calcarine fissure behind the splenium.

The **circular sulcus** (limiting sulcus of Reil) separates the insula from the frontal, parietal and temporal lobes; it surrounds the insula which lies concealed in the lateral fissure. On separating the upper and lower boundaries of the posterior ramus of the lateral fissure the insula will be exposed. The circular sulcus presents three limbs: an *upper limb* separating the insula from the frontal and parietal lobes; a *lower limb* separating it from the temporal lobe; and an *anterior limb* separating it from the orbital surface of the frontal lobe (Fig. 266).

The **cingulate sulcus** separates the cingulate gyrus from the superior frontal gyrus and the paracentral lobule. It begins below the anterior end of the corpus callosum and runs forwards and upwards; it then curves in front of the genu and passes backwards parallel to the callosal sulcus being separated from that sulcus by the cingulate gyrus. Its posterior end turns upwards and cuts the superomedial border behind the upper end of the central sulcus. Opposite the upper end of the precentral sulcus it sends an offset towards the superomedial border.

The **calcarine fissure** is a deep cleft which begins close to the occipital pole and, running forwards and slightly upwards, joins the parietooccipital fissure a little behind the splenium. It continues its course further forwards and ends below the splenium. The anterior part of this fissure gives rise to the eminence called the calcar avis in the lateral ventricle. The posterior and anterior parts of this fissure are developed separately at first and then become joined. Proof of this is furnished if the fissure is opened up behind its union with the parietooccipital fissure; a small gyrus, the *cuneolingual gyrus*, separating the anterior and posterior portions of this fissure will be seen. The calcarine fissure is functionally important for although the cortex of the occipital lobe in general is concerned with visual sensation the cortical area around the calcarine fissure is specially known as the *visual area* of the cortex. This portion of the cortical area presents a different appearance on section. If a coronal section of the occipital lobe is made across the posterior part of the calcarine fissure in a well preserved brain, a fine white line will be seen subdividing the grey substance round the calcarine fissure into an outer and an inner layer. This white line is called the *stria Gennari* (band of Gennari) and the cortical area showing this stria is called the *area striata*.

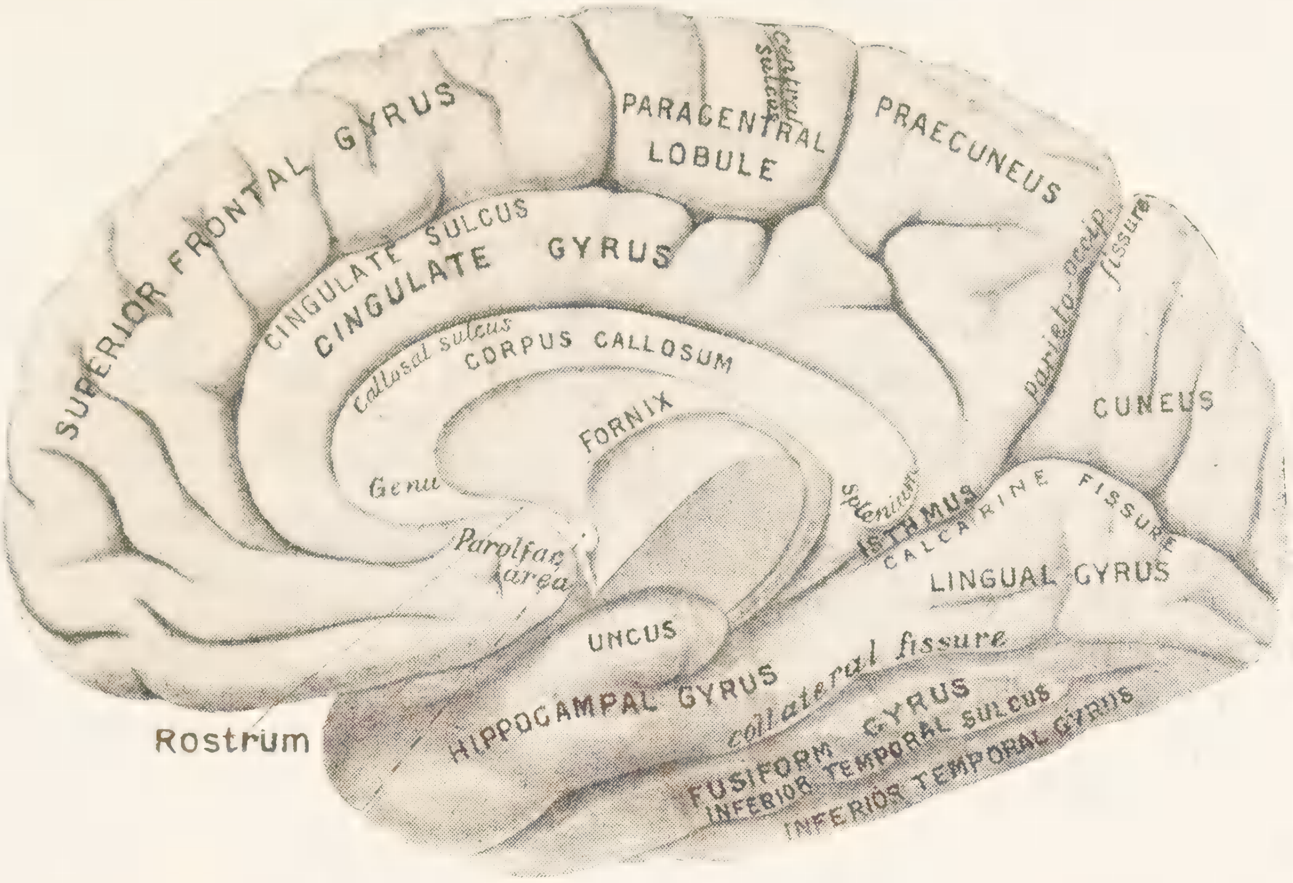


Fig. 264. The medial surface of the cerebral hemisphere.

The **subparietal sulcus** lies between the posterior end of the cingulate sulcus and the medial part of the parietooccipital fissure and separates the precuneus from the cingulate gyrus. It is in the same line with the back part of the cingulate sulcus excluding its upturned end.

The **collateral fissure** lies medial to the fusiform gyrus and separates it from the lingual gyrus behind and the hippocampal gyrus in front. Behind it is continued along the inferior surface of the occipital lobe and in front it terminates a little behind the temporal pole.

The **lobes** of each cerebral hemisphere are:—(1) frontal, (2) parietal, (3) temporal, (4) occipital, (5) insula, and (6) limbic.

The **frontal lobe** has three surfaces, lateral, inferior, and medial. On the lateral surface of the hemisphere, the frontal lobe is bounded behind by the central sulcus, below by the posterior ramus of the lateral fissure. Its inferior or orbital surface is bounded behind by the stem of the lateral fissure. Its medial surface is not demarcated from that of the parietal lobe by any fissure but a line drawn from the upper end of the central sulcus vertically downwards along the medial surface serves as the boundary line between the medial surfaces of the two lobes.

The **lateral surface** of the frontal lobe presents three main sulci which map out four gyri. The **sulci** are :—(1) The *precentral sulcus* lies in front of and parallel to the central sulcus. It consists of two parts, an upper and a lower, which are usually not connected with each other. (2) The *superior frontal sulcus* passes almost horizontally forwards from the upper part of the precentral sulcus. (3) The *inferior frontal sulcus* passes forwards and slightly downwards from the lower part of the precentral sulcus. The **gyri** are :—(1) The *anterior central gyrus* (ascending frontal convolution) which lies between the central and precentral sulci. It is the *motor area* of the cortex. (2) The *superior frontal gyrus* lies above the superior frontal sulcus and encroaches on the medial surface. It is frequently subdivided into an upper and a lower part by an antero-posterior furrow called the *paramedial frontal sulcus.* (3) The *middle frontal gyrus* lies between the superior and inferior frontal sulci and is limited behind by the precentral sulcus. This gyrus is also frequently subdivided into an upper and a lower part by the *medial frontal sulcus* of Eberstaller. (4) The *inferior frontal gyrus* lies in front of the precentral sulcus and below the inferior frontal sulcus. It is limited below by the superciliary border which separates it from the orbital surface. This gyrus is subdivided into three parts by the anterior horizontal and anterior ascending rami of the lateral fissure. The portion lying below the anterior horizontal ramus is called the *pars orbitalis.* The portion lying between the anterior horizontal and anterior ascending rami is called the *pars triangularis.* The portion lying behind the anterior ascending ramus is called the *pars basilaris.* The left inferior frontal gyrus is called Broca's convolution as Broca localised it as the centre for articulate speech.

The **inferior** or **orbital surface** of the frontal lobe presents two sulci ; the olfactory sulcus and the **H**-shaped orbital sulcus. The *olfactory sulcus* lies close to the medial orbital border and lodges the olfactory tract and bulb. The **H**-shaped *orbital sulcus* lies lateral to the olfactory sulcus and presents two antero-posterior limbs, one medial and the other lateral, connected in the middle by a transverse limb resembling the letter **H**. The orbital surface of the frontal lobe is mapped out into five gyri. (1) The *gyrus rectus* lies between the medial border and the olfactory sulcus. (2) The *medial orbital gyrus* lies between the olfactory sulcus and the medial limb of the **H**-shaped orbital sulcus. The gyrus rectus and the medial orbital gyrus are continuous with the superior frontal gyrus on the lateral surface of the hemisphere. (3) The *anterior orbital gyrus* lies in front of the transverse limb of the orbital sulcus. It is continuous with the middle frontal gyrus. (4) The *lateral orbital gyrus* lies lateral to the lateral limb of the orbital sulcus and is continuous with the inferior frontal gyrus. (5) The *posterior orbital gyrus* lies behind the transverse limb of the orbital sulcus. It is also continuous with the inferior frontal gyrus on the lateral surface.

The **medial surface** of the frontal lobe presents only one gyrus viz., the medial portion of the superior frontal gyrus. It is situated between the superomedial border of the hemisphere and the cingulate sulcus. Its posterior part is often detached and forms the *paracentral lobule* so called on account of its containing the upper end of the central sulcus ; it is bounded in front by the offset of the cingulate sulcus and behind by the upturned end of the same sulcus ; it is continuous with the anterior and posterior central gyri.

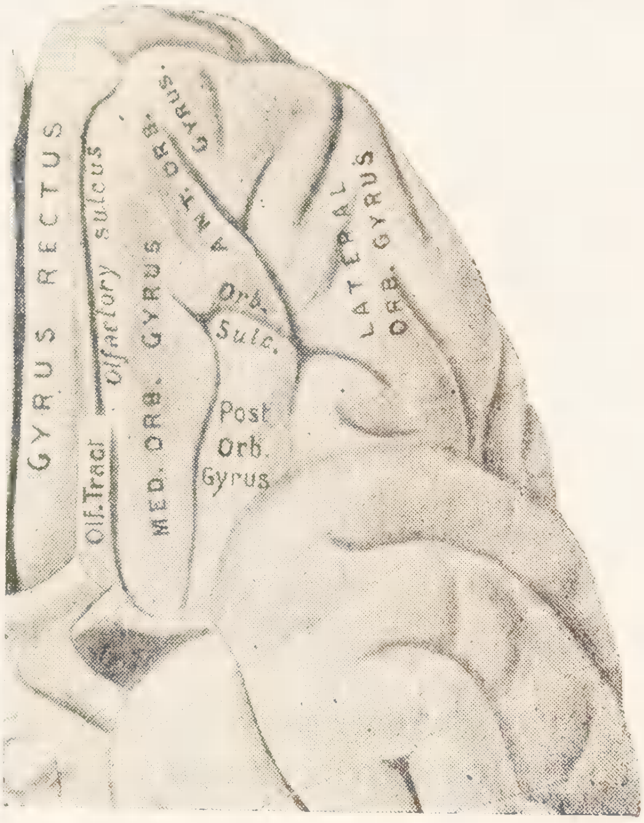


Fig. 264.—The orbital surface of the frontal lobe.

The **parietal lobe** has two surfaces, lateral and medial. The **lateral surface** of the parietal lobe is **bounded** in front by the central sulcus, behind by the lateral part of the parietooccipital fissure and by a line drawn from the lower extremity of this fissure to the preoccipital notch, below by the posterior ramus of the lateral fissure and an imaginary line drawn backwards in continuation of the same ramus to meet the posterior boundary. It presents the following **sulci** :—(1) The *postcentral sulcus* lies behind and parallel to the central sulcus. It is usually interrupted in the middle and is then described as consisting of an upper and a lower branch. (2) The *intraparietal sulcus* passes almost horizontally backwards from the middle of the postcentral sulcus. It is prolonged behind into the occipital lobe as the *occipital ramus* of the intraparietal sulcus and terminates by joining the transverse occipital sulcus behind the lateral parieto-occipital fissure. Sometimes there is an interruption between the occipital ramus and the intraparietal sulcus.

The **gyri** on the lateral surface of the parietal lobe are :—(1) The *posterior central gyrus* (ascending parietal convolution) lies between the central sulcus in front and the postcentral sulcus behind. It is continuous in front with the anterior central gyrus round the upper and lower ends of the central sulcus. It is the cortical area for general sensibility (*sensory area*). (2) The *superior parietal lobule* is bounded in front by the upper part of the postcentral sulcus and is continuous in front with the posterior central gyrus above the upper end of that sulcus. Behind it is the lateral parietooccipital fissure; below the lower end of this fissure it is connected with the occipital lobe by a connecting gyrus called the *arcus parietooccipitalis*; below it is bounded by the intraparietal sulcus. (3) The *inferior parietal lobule* is bounded in front by the lower part of the postcentral sulcus, above by the intraparietal sulcus, below by the lower boundary of the parietal lobe, and behind by the imaginary line which bounds the parietal lobe posteriorly. This lobule is further subdivided into two gyri, viz., (*a*) the *supramarginal gyrus* which surroundss the upturned end of the posterior ramus of the lateral fissure and is continuous in front with the posterior central gyrus and behind with the superior temporal gyrus; (*b*) the *angular gyrus* which surrounds the upturned end of the superior temporal sulcus.

The **medial surface** of the parietal lobe presents a quadrilateral outline and constitutes the precuneus or quadrate lobe. The *precuneus* or *quadrate lobe* corresponds to the medial surface of the superior parietal lobule. It is bounded in front by the upturned end of the cingulate sulcus, behind by the medial part of the parietooccipital fissure, above by the superomedial border and below by the subparietal sulcus.

The **occipital lobe** forms the posterior part of the hemisphere and presents a lateral, an inferior, and a medial surface. Its **lateral surface** is bounded in front by the lateral part of the parietooccipital fissure and by a line drawn from its lower end to the preoccipital notch. The *sulci* on its lateral surface are:—(1) The *transverse occipital sulcus* lies behind the lateral part of the parietooccipital fissure and which is joined in front by the occipital ramus of the intraparietal sulcus. (2) The *lateral occipital sulcus* passes from behind forwards on the lateral surface of the occipital lobe. The *gyri* on its lateral surface are:—(1) The *superior occipital gyrus* lies above the lateral occipital sulcus. (2) The *inferior occipital gyrus* lies below the same sulcus. (3) The *arcus parietooccipitalis* lies in front of the transverse occipital sulcus and has been already described.

The **inferior** or **tentorial surface** of the occipital lobe is continuous in front with the inferior surface of the temporal lobe and is demarcated from it by an imaginary line passing transversely medialwards from the preoccipital notch. This surface presents the posterior portion of the collateral fissure which separates the lower portion of the lingual gyrus above from the posterior portion of the fusiform gyrus below.

The **medial surface** of the occipital lobe presents the calcarine fissure which subdivides this surface into two gyri, the cuneus and lingual gyrus. The *cuneus* is a wedge-shaped or triangular gyrus lying between the medial part of the parietooccipital fissure and the calcarine fissure. The *lingual gyrus* lies between the calcarine and collateral fissure. It occupies both the medial and inferior surfaces of the hemisphere. It is continuous in front with the hippocampal gyrus.

The **temporal lobe** is situated below the posterior ramus of the lateral fissure and in front of the occipital lobe and presents three surfaces. Its **lateral surface** is mapped out into three gyri by two sulci. The **sulci** are :—(1) The *superior temporal sulcus* (parallel sulcus) lies below the posterior ramus of the lateral fissure and runs parallel to it. It extends from near the temporal pole to a point a little behind the upturned end of the posterior ramus of the lateral fissure. (2) The *middle temporal sulcus* lies below the preceding and runs parallel to it. It is often interrupted in the middle. The **gyri** are :—(1) The *superior temporal gyrus* lies between the posterior ramus of the lateral fissure and the superior temporal sulcus. It is continuous behind with the supramarginal gyrus. (2) The *middle temporal gyrus* lies between the superior and middle temporal sulci. It is continuous behind with the angular gyrus. (3) The *inferior temporal gyrus* lies below the middle temporal gyrus and is continuous behind with the inferior occipital gyrus.

The **inferior surface** of the temporal lobe is concave and presents the following **sulci** :—(1) The *inferior temporal sulcus* lies most laterally and runs anteroposteriorly between the temporal and occipital poles. It is often interrupted and it separates the inferior temporal gyrus laterally from the fusiform gyrus lying medially. (2) *Collateral fissure.*—It has been described (p. 527). (3) *Chorioidal fissure.*—A portion of this fissure extends from below the splenium towards the anterior end of the temporal lobe. It forms the upper and medial boundary of the inferior surface of the temporal lobe and through it a vascular fold of pia mater, the chorioid plexus, enters the inferior cornu of the lateral ventricle. (4) The stem of the *calcarine fissure*. The **gyri** on the inferior surface of the temporal lobe are :—(1) The *inferior temporal gyrus* lies lateral to the inferior temporal sulcus and is continuous with the same gyrus seen on the lateral surface. (2) The *fusiform gyrus* lies between the inferior temporal sulcus and the collateral fissure. Behind it is continuous with the inferior surface of the occipital lobe. (3) The *hippocampal gyrus* lies between the collateral and chorioidal fissures. Its anterior extremity is bent upwards on itself like a hook and is called the *uncus*. The uncus is separated from the temporal pole by a slight cleft called the *incisura temporalis*. Behind and below the hippocampal gyrus is continuous with the lingual gyrus ; behind and above, with the cingulate gyrus lying above the corpus callosum. The cortical area for the sense of taste is in the hippocampal gyrus and the uncus.

The **superior surface** of the temporal lobe presents some gyri concealed in the posterior ramus of the lateral cerebral fissure. These gyri pass from behind forwards and lateralwards and are called the *transverse temporal gyri* and they overlap the insula. The anterior transverse temporal gyrus and the middle third of the superior temporal gyrus together form the cortical centre for auditory sensation or hearing (*audito-sensory area*).

The **insula** (island of Reil) (Fig. 266) lies concealed at the bottom of the lateral cerebral fissure. To see the insula it is necessary to separate widely the lips of that fissure. It is then seen as a somewhat triangular eminence with its apex at the commencement of the stem of that fissure. The insula is surrounded by the circular sulcus. The gyri which bound the lateral cerebral fissure overlap and hide the insula and are called the *opercula of the insula*. These opercula, four in number, are separated from each other by the three limbs of the lateral fissure and are named the orbital, frontal, frontoparietal, and temporal opercula. The *orbital operculum* lies below the anterior horizontal ramus of the lateral fissure. The *frontal operculum* lies between the anterior ascending and anterior horizontal rami. The *fronto-parietal operculum* lies between the anterior ascending ramus and the terminal part of the posterior ramus of the lateral fissure. The *temporal operculum* lies below the posterior ramus and is formed by the upper margin of the superior temporal gyrus.

*Gyri of the insula.*—These are best displayed when the opercula are removed. The surface of the insula is subdivided by a sulcus called the *sulcus centralis insulae*. It runs from the apex of the insula upwards and backwards. The gyri lying in front of the sulcus are three or four in number and are called *short gyri*, while the gyrus lying behind the sulcus is long and is called the *long gyrus*.

**Limbic lobe.**—This name was introduced by Broca in 1878. This lobe is situated on the medial surface of the cerebral hemisphere and consists of two gyri, the cingulate gyrus and hippocampal gyrus which are disposed like a ring round the corpus callosum and callosal and hippocampal fissures.

The *cingulate gyrus* is a curved convolution lying between the callosal fissure below and the cingulate and subparietal sulci above. It surrounds the corpus callosum and is connected behind the splenium with hippocampal gyrus by a narrow gyrus, called the *isthmus*, which lies between the splenium and the anterior end of the calcarine fissure.

The *hippocampal gyrus* has been described (p. 531).

The *callosal sulcus* is a slit-like interval lying between the convex surface of the corpus callosum and the cingulate gyrus.

The *hippocampal fissure* commences behind the splenium of the corpus callosum; it is directed forwards lying between the dentate gyrus above and hippocampal gyrus below and terminates in the uncus. It is a complete fissure and gives rise to the elevation called the hippocampus which is seen in the inferior cornu of the lateral ventricle.

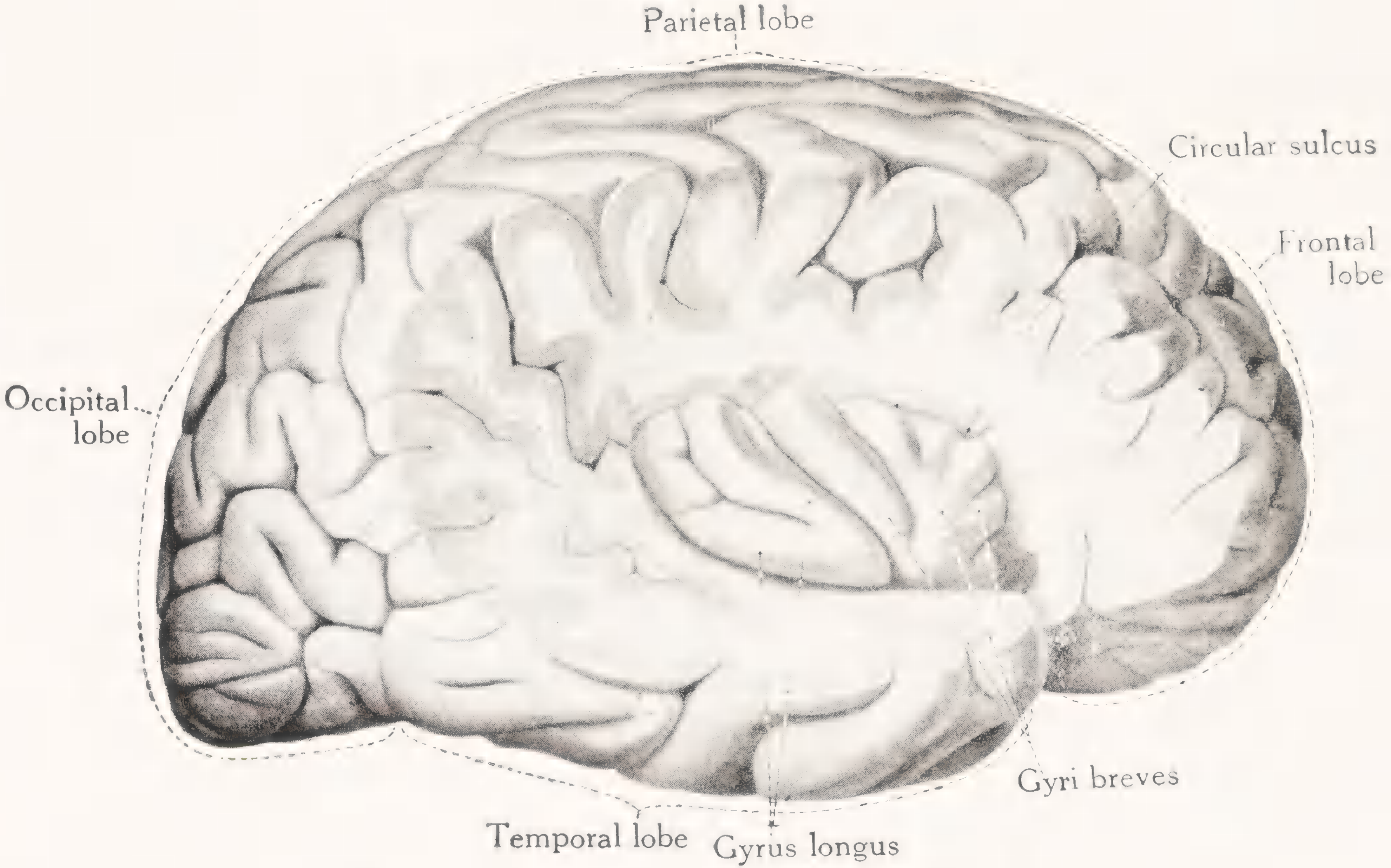


Fig. 266. - The insula exposed by removing the opercula.

To face p. 532.

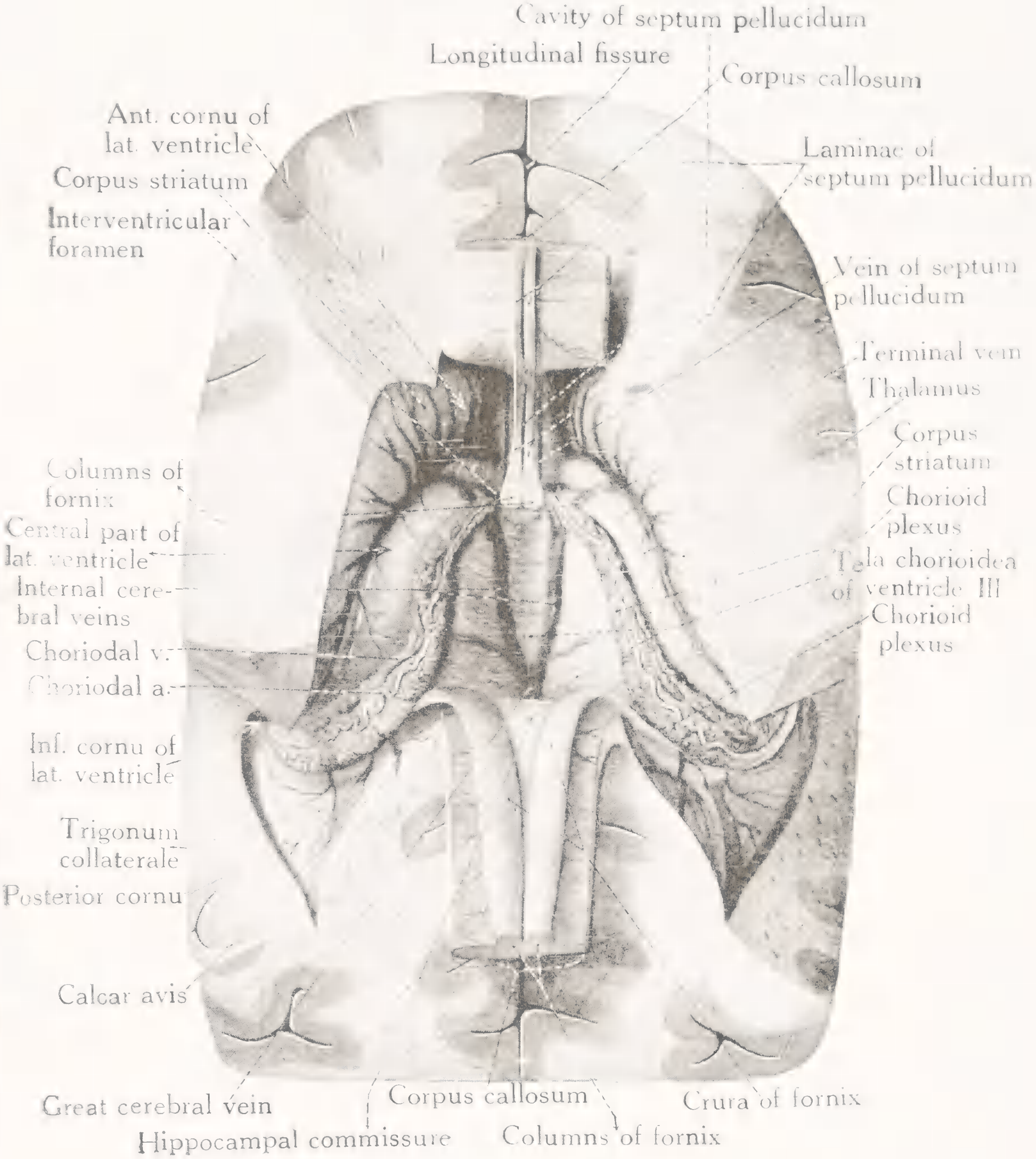


Fig. 269.- The lateral ventricles and the tela chorioidea.

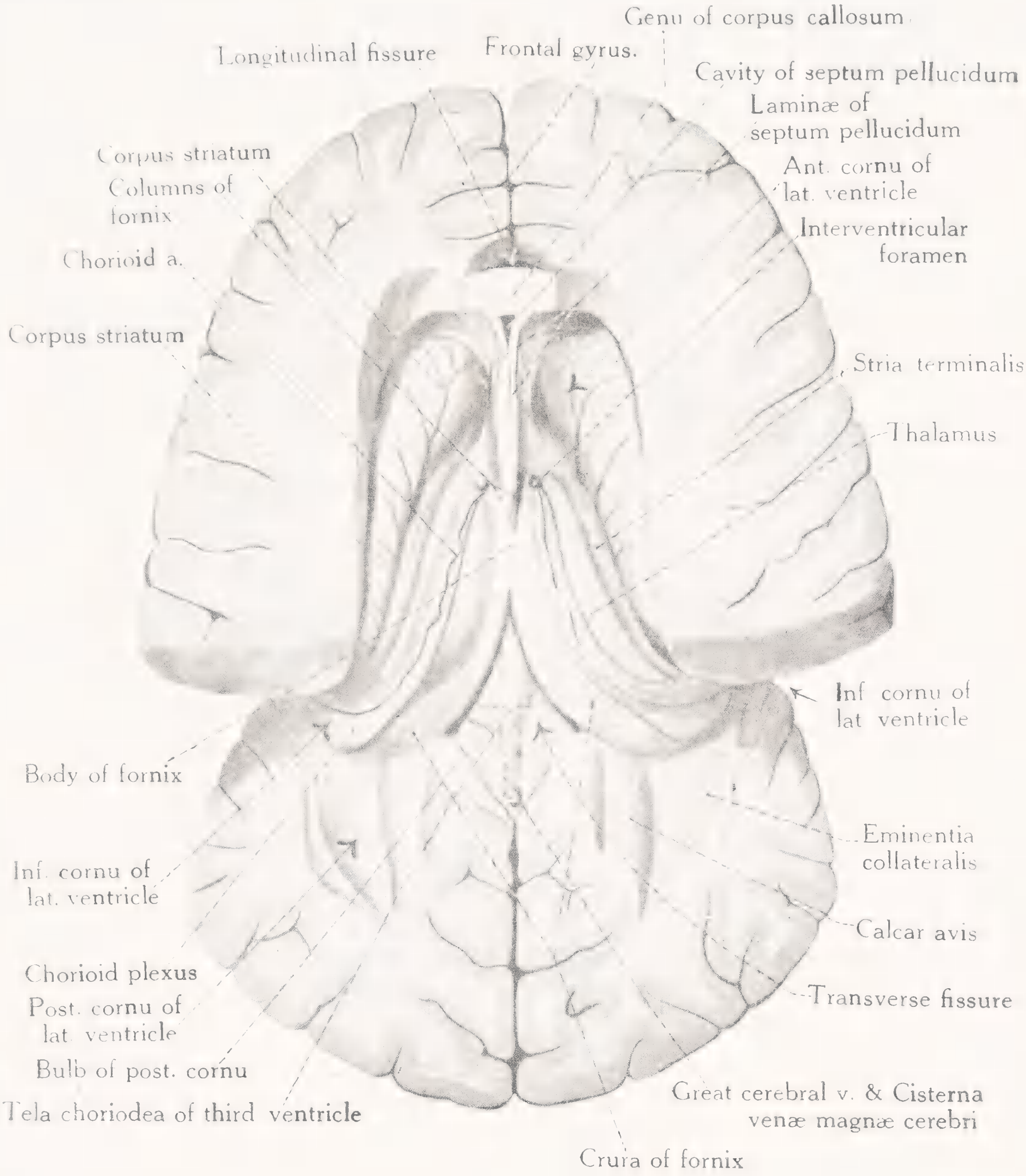


Fig. 270.—The lateral ventricles, fornix and septum pellucidum.

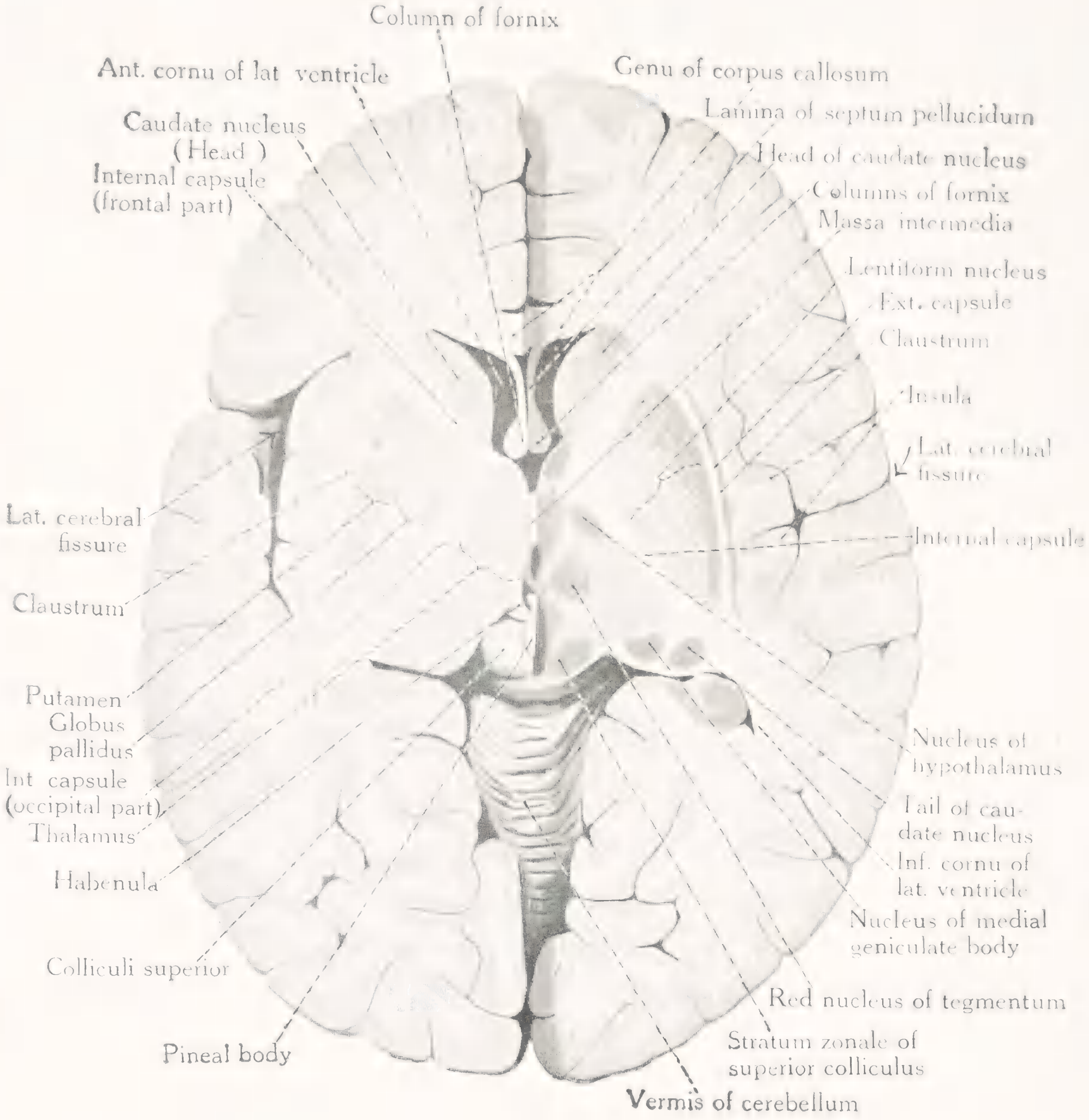


Fig. 271.—The basal ganglia and the internal capsule.

To face p. 533.

## The Rhinencephalon

The rhinencephalon consists of the following parts: (1) the olfatory lobe, (2) the uncus, (3) the hippocampus, (4) the septum pellucidum, (5) the fascia dentata hippocampi, (6) the subcallosal gyrus, (7) the supracallosal gyrus, and (8) the fornix.

**Olfactory lobe** (Fig. 254).—This name is given to the following parts lying in continuity:—(1) The olfactory bulb, (2) the olfactory tract, (3) the olfactory trigone, (4) the parolfactory area of Broca, and (5) the anterior perforated substance.

The *olfactory bulb* is the enlarged anterior end of the olfactory tract. It lies in the groove on the upper surface of the lamina cribrosa of the ethmoidal bone. To its lower surface are attached the olfactory nerve filaments.

The *olfactory tract* is the narrow part behind the olfactory bulb. It lies in the olfactory sulcus on the orbital surface of the frontal lobe. It is triangular on section, the apex of the triangle being received into the olfactory sulcus.

The *olfactory trigone* is the triangular elevation at the back part of the olfactory tract and in front of the anterior perforated substance. From the lateral angle of the olfactory trigone the *lateral olfactory stria* passes along the lateral margin of the anterior perforated substance to the uncus of the hippocampal gyrus. From the medial angle of the olfactory trigone the *medial olfactory stria* passes along the medial aspect of the trigone medialwards to the subcallosal gyrus situated beneath the anterior part of the corpus callosum.

The *parolfactory area of Broca* is a small triangular area situated in front of the subcallosal gyrus on the medial surface of the hemisphere and separated from it by a sulcus called the *posterior parolfactory sulcus*.

The *anterior perforated substance* is so called on account of its being perforated by blood vessels, viz., the anterolateral ganglionic arteries. It is bounded in front by the olfactory trigone, behind by the optic tract, laterally by the lateral olfactory stria, and medially by the medial olfactory stria.

The *uncus* is the bent anterior extremity of the hippocampal gyrus (p. 531). The hippocampus, fornix and septum pellucidum will be described in the Section on the lateral ventricle. The *subcallosal gyrus* (peduncle of the corpus callosum) is a ridge of grey substance which descends from the rostrum of the corpus callosum and runs towards the parolfactory area and anterior perforated substance.

The *fascia dentata hippocampi* (dentate gyrus) is a narrow band which lies on the upper surface of the hippocampal gyrus. Its free surface is marked by ridges and furrows and is covered by the fimbria hippocampi. The cleft between it and the fimbria hippocampi is called the *fimbriodentate sulcus*. Behind it is continuous with the fasciola cinerea beneath the splenium. In front it is continued into the uncus as a curved band called the *band of Giacomini*.

The *supracallosal gyrus* or *indusium griseum* is a thin layer of grey substance covering the upper surface of the corpus callosum. Traced in front it is seen to be prolonged round the genu and the rostrum to be continuous with the subcallosal gyrus. Traced behind it is continued below the splenium as a thin ridge, called the *fasciola cinerea,* into the fascia dentata hippocampi.

### The Interior of the Cerebral Hemispheres

If both the cerebral hemispheres are sliced off to the level of the upper surface of the corpus callosum, a large mass of white substance which consists of the corpus callosum and the white areas of the two hemispheres, is seen. This large white area is known as the *centrum ovale.*

The **corpus callosum** (Figs. 264, 269) is the great transverse commissure which connects the two cerebral hemispheres. It consists of a thick stratum of white substance composed mainly of transverse fibres. It is situated at the bottom of the longitudinal fissure and measures about 4 inches anteroposteriorly. It is nearer to the frontal than to the occipital pole, and is thicker at the ends than at the middle. Its *superior surface* is convex from before backwards and forms the floor of the central portion of the longitudinal fissure; it is touched by the falx cerebri posteriorly but anteriorly that process does not descend low enough to reach it. It is covered by a very thin layer of grey substance, called the *supracallosal gyrus,* and is overlapped laterally by the cingulate gyrus. It presents along the middle line a faint anteroposterior groove. On either side of this groove is a thin linear elevation in the supracallosal gyrus formed by longitudinal fibres, called the *stria longitudinalis medialis.* Lateral to this on either side is another longitudinal linear elevation called the *stria longitudinalis lateralis.* The *inferior surface* forms the roof of the lateral ventricles; along its middle, the septum pellucidum is attached in front and the fornix, behind. The *anterior end* of the corpus callosum is bent and then reflected downwards and backwards; the bend is called the *genu* and the reflected portion, the *rostrum.* The rostrum gradually becomes thinner and is connected below with the lamina terminalis. The *posterior end* of the corpus callosum is the thickest part and is rounded and free; it is called the *splenium.*

**Destination of the fibres of the corpus callosum.**—The transverse fibres of the corpus callosum as they enter the white medullary substance of each cerebral hemisphere transverse it in a radiating manner and reach the cerebral cortex—these diverging fibres are known as the *radiatio corporis callosi* and they intersect in their course the fibres which form the corona radiata i.e. those fibres which extend between the internal capsule and cerebral cortex. The fibres from the genu on entering the hemisphere radiate forwards to the frontal lobe forming what is called the *forceps anterior* (minor). The fibres from the splenium on entering the hemisphere pass backwards towards the occipital lobe forming the *forceps posterior* (major). The intermediate fibres sweep across the roof and lateral wall of the lateral ventricle into the temporal lobe forming what is called the *tapetum.*

The **lateral ventricles** (Figs. 267 to 270) are two irregular cavities, one in each hemisphere of the brain, and are separated from each other by a median partition extending from the floor to the roof called the *septum pellucidum.* They are lined by a thin membrane called the *ependyma* and contain a serous fluid called the cerebrospinal fluid. They communicate with the third ventricle by an aperture, called the *interventricular foramen,* which is placed in front of the anterior end of the thalamus. Each lateral ventricle consists of a central part, an anterior cornu, a posterior cornu, and an inferior cornu.

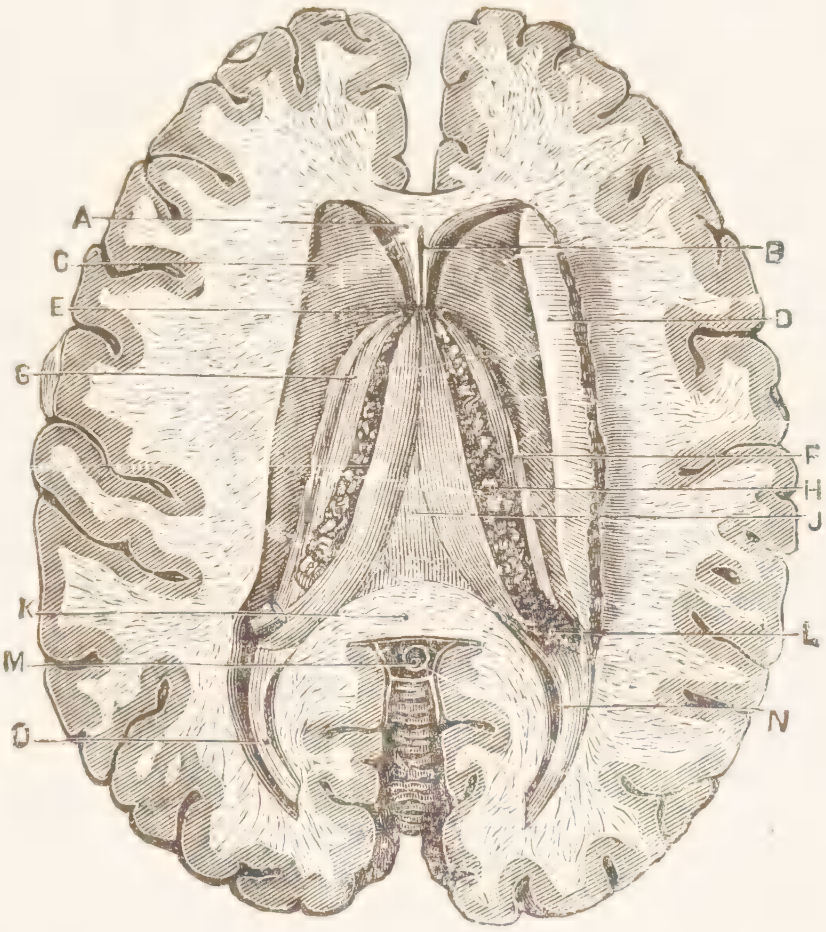


Fig. 267.—Lateral ventricles of the brain.

A. Septum pellucidum.
B. Cavum septum pellucidi.
C. Corpus striatum.
D. Corpus callosum, reflected.
E. Interventricular foramen.
F. Stria terminalis
G. Thalamus.
H. Chorioid plexus.
J. Fornix.
K. Posterior extremity of corpus callosum.
L. Commencement of inferior cornu.
M. Great cerebral vein.
N. Calcar avis.
O. Posterior cornu of lateral ventricle.

The **central part** (body) extends from the splenium of the corpus callosum behind to the interventricular foramen in front. Its *roof* is formed by the under surface of the corpus callosum and its *medial wall* by the back part of the septum pellucidum. *Laterally* the roof meets with the floor. Its *floor* is formed from before backwards by (1) the caudate nucleus, (2) the terminal vein, (3) the stria terminalis, (4) the thalamus, (5) the chorioid plexus, and (6) the fornix. The *caudate nucleus* is a mass of grey substance; it will be described with the basal ganglia. The *terminal vein* (vein of the corpus striatum) is placed in the same groove occupied by the stria terminalis; it opens into the internal cerebral vein at the interventricular foramen. The *stria terminalis* (tænia semicircularis) lies in the groove between the caudate nucleus and the thalamus. It is a linear band of white substance which passes in front towards the interventricular foramen. Behind it passes into the roof of the inferior cornu. A very narrow portion of the lateral part of the upper surface of the *thalamus* is seen between the chorioid plexus and the stria terminalis. The *chorioid plexus* is a vascular fringe of pia mater which appears in the lateral ventricle between the lateral edge of the fornix and the thalamus. The lateral edge of the body of the *fornix* is seen in the central part of the lateral ventricle; it is thin and it overlaps the chorioid plexus. Each lateral ventricle communicates with the third ventricle by means of an aperture called the *interventricular foramen* which is bounded in front by the column of the fornix and behind by the anterior end of the thalamus.

The **anterior cornu** (anterior horn) lies in front of the interventricular foramen. It passes forwards, lateralwards and slightly downwards into the frontal lobe. Its *roof* is formed by the front part of the corpus callosum; its *floor* by the orbital part of the frontal lobe; its *medial wall* by the front part of the septum pellucidum; and its *lateral wall* by the head of the caudate nucleus.

The **posterior cornu** extends backwards into the occipital lobe. It is curved; the convexity of the curve is directed lateralwards. Its *roof* and *lateral wall* are formed by the tapetum of the corpus callosum. Its *medial wall* presents two elongated elevations. The upper of the two is called the *bulb of the posterior*

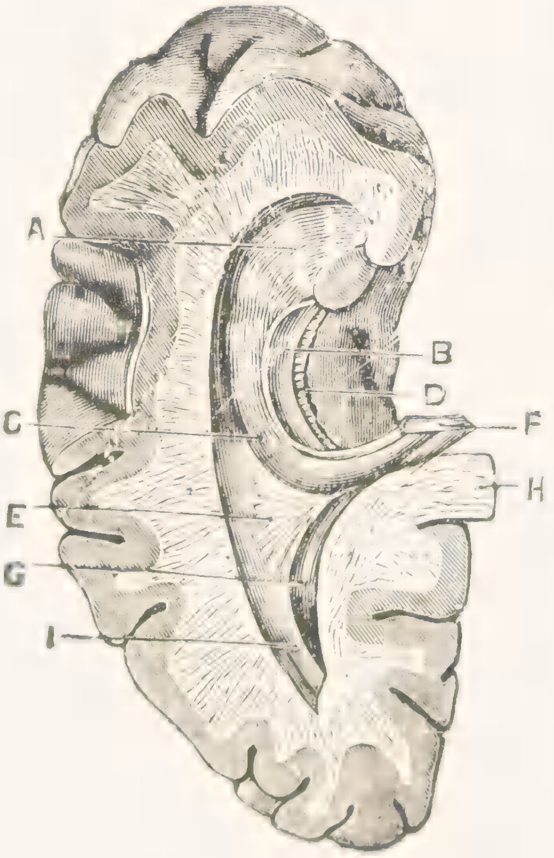


Fig. 268.—Inferior and posterior cornua of the lateral ventricle of brain.

A. Pes hippocampi.
B. Fimbria hippocampi.
C. Hippocampus.
D. Fascia dentata.
E. Eminentia collateralis.
F. Crus of fornix (cut).
G. Calcar avis (the forceps posterior is seen on the medial side of this in continuity with the splenium).
H. Splenium of corpus callosum (cut).
I. Posterior cornu.

*cornu* and is formed by the fibres of the forceps posterior. The lower elevation is called the *calcar avis* (hippocampus minor) and is caused by the infolding of the ventricular wall of the anterior part of the calcarine fissure. The posterior extremity of the posterior cornu is tapering.

The **inferior cornu** (descending horn) of the lateral ventricle runs into the temporal lobe and passes at first backwards and lateralwards and then turns downwards and forwards and finally bends medialwards ending about an inch behind the temporal pole. Its *lateral wall* is formed mostly by the tapetum Its *medial wall* presents the lower part of the chorioidal fissure which is seen when the chorioid plexus is removed. Its *roof* is formed chiefly by the tapetum but the tail of the caudate nucleus also passes forwards in the roof to terminate in a small nucleus of grey substance called the *amygdaloid nucleus.* This nucleus produces an elevation in the anterior end of the roof. The stria terminalis also lies in the roof and terminates in the amygdaloid nucleus. The *floor* of the inferior cornu presents the following parts : (1) the hippocampus, (2) the fimbria hippocampi, (3) the collateral eminence, (4) the chorioid plexus, and (5) the trigonum collaterale.

The **hippocampus** (hippocampus major) is an elongated conspicuous eminence, occupying the whole length of the floor of the inferior cornu. It rigidly follows the curve of the cornu and at its lower end becomes expanded and indented on the surface so as to resemble the paw of an animal. Hence this terminal portion is called the *pes hippocampi.* The amygdaloid nucleus lies on the roof opposite the pes hippocampi. The hippocampus is covered by the chorioid plexus. In structure it consists principally of grey substance but has a thin layer of white substance on the ventricular surface termed the *alveus.*

The **fimbria hippocampi** (corpus fimbriatum, tænia hippocampi) is a narrow band of white substance which is attached to the medial concave border of the hippocampus. It is continuous above with the crus of the fornix and terminates below at the uncus. Its medial margin is free. Laterally it is continuous with the thin layer of white substance, called the alveus, already referred to.

The **collateral eminence** is an elongated projection on the floor of the inferior cornu situated on the lateral side of the hippocampus. It is continuous behind with the triangular area called the trigonum collaterale. It is produced by an infolding of the ventricular wall corresponding to the middle part of the collateral fissure.

The *chorioid plexus* is the vascular fringe of pia mater which has been pushed into the inferior cornu of the lateral ventricle through the chorioidal fissure.

The *trigonum collaterale* is the smooth triangular space seen in the floor of the inferior cornu at the angle of divergence of the posterior and inferior cornua.

The **septum pellucidum** (septum lucidum) is the partition between the anterior cornua and the anterior parts of the central portions of the lateral ventricles. It consists of two thin laminæ, separated from each other by a narrow chink called the *cavity of the septum pellucidum* (fifth ventricle). This cavity is considered to be a portion of the longitudinal cerebral fissure and does not communicate with the ventricles of the brain. The septum pellucidum is attached above to the under surface of the corpus callosum and below to the rostrum in front and to the fornix behind.

The **fornix** (Figs. 269, 270) is a band of white substance situated below the corpus callosum. It extends from before backwards in the form of an arch, the convexity of which is directed upwards. It consists of two lateral halves, the central parts of which are joined together in the middle line while their anterior and posterior parts diverge from each other. The central joined parts constitute the body; the anterior parts are called the columns of the fornix; and the posterior parts, the crura.

The *body* of the fornix is triangular, being narrow in front and broad behind. Its upper surface, in the median line, is attached behind to the under surface of the corpus callosum and in front to the septum pellucidum. The lateral portions of the upper surface form the floor of the lateral ventricles. Its lower surface rests on the fold of pia mater which forms the roof of the third ventricle. Its lateral border is separated from the thalamus by the chorioid plexus.

The *columns* of the fornix (anterior pillars) pass downwards in front of the interventricular foramen. Each column passes under cover of the ependyma of the lateral wall of the third ventricle to the base of the brain to terminate in the corpus mamillare. From here a fresh bundle of fibres, called the *mamillothalamic fasciculus* (bundle of Vicq d'Azyr), arises and passes to the anterior nucelus of the thalamus.

The *crura* of the fornix (posterior pillars) are the posterior prolongations from the body of the fornix and are at first attached to the under surface of the corpus callosum. Each crus diverges from its fellow of the opposite side and curves lateralwards and downwards round the posterior end of the thalamus; it then proceeds into the inferior cornu of the lateral ventricle and lies along the concavity of the hippocampus. Some of its fibres spread out over the hippocampus forming the alveus; the remainder form a band and become continuous with the fimbria hippocampi in the inferior cornu of the lateral ventricle. If the body of the fornix is cut through transversely at its middle and the posterior portion thrown backwards, a triangular lamina will be seen between the diverging crura encroaching on the back part of the under surface of the body of the fornix. This lamina is called the *lyra* and it is traversed by transverse fibres connecting the two crura and through them the hippocampi of the two sides.

These transverse fibres constitute a commissure called the *hippocampal commissure*. Each lateral half of the fornix establishes communication between (1) the hippocampus—because most of the fibres of the fornix arise in this eminence, and (2) the thalamus of the same side—through the column of the fornix, the corpus mamillare, and the mamillothalamic fasciculus.

The *anterior commissure* is a rounded bundle of white fibres which lies transversely just in front of the columns of the fornix. It connects the two temporal lobes in as much as its fibres can be traced downwards and backwards into the substance of the temporal lobe.

The **chorioidal fissure** in its entirety extends from the interventricular foramen to the end of the inferior cornu and is in reality the lateral part of the transverse fissure of the brain. It is an artificial gap which is produced when the chorioid plexus is pulled away and as a result of this the exterior of the brain leads directly into the interior of the inferior cornu. Its upper part begins at the interventricular foramen and passes backwards between the lateral margin of the body of the fornix and the upper surface of the thalamus. At the commencement of the inferior cornu the fissure lies between the crus of the fornix and the posterior end of the thalamus. In the inferior cornu it lies between the stria terminalis on the roof and the fimbria hippocampi on the floor of the cornu. Through the fissure the chorioid plexus protrudes into the central part and into the inferior cornu of the lateral ventricle pushing the ependyma before it.

The **chorioid plexus** is a system of convoluted blood vessels enclosed within a fold of pia mater projecting in the ventricular cavity. The whole of this plexus is clothed by a layer of epithelium which is continuous with the epithelial lining of the ventricle. Commencing at the interventricular foramen where it joins the plexus of the opposite side, it is prolonged into the inferior cornu and the central part of the lateral ventricle. From the junction of the two plexuses, two other chorioid plexuses extend backwards on the under surface of the tela chorioidea, one on either side of the median line, and constitute the chorioid plexuses of the third ventricle. The plexus contains veins and arteries. The veins eventually form a single vein which reaching the interventricular foramen joins the terminal vein. The arteries are derived from the anterior chorioidal branch of the internal carotid and the posterior chorioidal branch of the posterior cerebral artery.

The **tela chorioidea of the third ventricle** (velum interpositum) is a double layer of pia mater which penetrates into the ventricles through the central portion of the transverse fissure beneath the splenium. It is placed beneath the body of the fornix forming the roof of the third ventricle. It is triangular in shape; its apex reaches as far forwards as the interventricular foramen; and its base lies under the splenium at the transverse fissure.

Along its lateral margin is the chorioid plexus of the lateral ventricle which protrudes into the central portion of the lateral ventricle through the upper part of the chorioidal fissure. From its under surface, on either side of the middle line, a linear vascular fringe projects downwards into the third ventricle; this fringe is called the *chorioid plexus of the third ventricle.* Between the two layers of the tela chorioidea are contained the *internal cerebral veins* (veins of Galen) one on either side. Each of these veins is formed in front at the interventricular foramen by the union of the terminal vein with the chorioidal vein. Emerging from the chorioid plexus the internal cerebral vein proceeds backwards close to the median line, receives the basal vein of the same side and unites with its fellow of the opposite side forming the *great cerebral vein* (vena magna Galeni) which opens into the straight sinus.

The **transverse fissure of the brain** is the cleft through which the invagination of the pia mater forming the tela choriodea of the third ventricle, and that of the chorioid plexus of the inferior cornu of the lateral ventricle into the interior of the brain, takes place. It consists of a central and two lateral portions. The central portion lies between the splenium and body of the fornix above, and the mid-brain below; the base of the tela chorioidea of the third ventricle lies along it. The two lateral portions coincide with the lower parts of the chorioidal fissure. The transverse fissure must be differentiated from the chorioidal fissure. The lateral portions of the former are the same as the lower portions of the latter, but the central portion of the transverse fissure does not coincide with the upper part of the chorioidal fissure. The upper part of the latter fissure lies between the lateral margin of the fornix and the thalamus.

### The Basal Ganglia of the Cerebral Hemispheres

The basal ganglia (Fig. 271) are certain masses of grey substance more or less completely embedded in the white medullary substance of the hemisphere. They are (1) the caudate and lentiform nuclei which together constitute the corpus striatum, (2) the claustrum, and (3) the amygdaloid nucleus. Under this heading the internal and external capsules are also described.

The **corpus striatum** is a large mass of grey substance situated in front of and to the lateral side of the thalamus. It is composed of two parts: (1) a superomedial part, which projects into the lateral ventricle and this portion is called the *intraventricular portion* or the caudate nucleus; (2) an inferolateral part which is embedded in the white substance of the cerebral hemisphere and is called the *extraventricular portion* or lentiform nulceus.

The **caudate nucleus** is a pear-shaped mass of grey substance. It presents a broad anterior extremity or *head* which projects into the anterior cornu of the lateral ventricle; and a narrow tapering posterior extremity or *tail* which lies on the lateral side of the thalamus and is prolonged downwards along the roof of the inferior cornu to terminate at the amygdaloid nucleus. It is separated in the greater part of its extent from the lentiform nucleus by a thick layer of white substance, the internal capsule, but is fused with that nucleus in front.

The **lentiform nucleus** is seen only in sections of the hemisphere. When seen in hori ontal section it presents the appearance of a biconvex lens. It is broader above than below. It is bounded laterally by a thin layer of white substance called the external capsule, and medially by the internal capsule in the concavity of which it lies. It is continuous above and in front with the head of caudate nucleus and below with the anterior perforated substance. The substance of the lentiform nucleus is subdivided into three segments by two antero-posterior vertical laminæ of white substance called the *medullary laminae*. Of these three segments the medial two are of a lighter colour and are together called the *globus pallidus* while the lateral segment is of a darker colour and is called the *putamen*—all three are traversed by fine white fibres which are well-marked in the putamen.

**Connections of the corpus striatum.**—The connections of the two grey masses which constitute the corpus striatum are important because they explain the functions of this body in exercising the steadying influence upon muscles performing voluntary movements. (1) The corpus striatum is connected with the cerebral cortex by *corticostriate fibres*. (2) The corpus striatum is connected with the thalamus by striothalamic and thalmostriate fibres. (3) The caudate nucleus is connected with the substantia nigra by a bundle of fibres called the *fasciculus strionigricus*. (4) The lentiform nucleus is connected with the thalamus by a bundle of fibres called the *ansa lentiformis*. (5) The caudate and lentiform nuclei are connected with each other by striæ of grey substance.

The **claustrum** is a thin lamina of grey substance lying between the external capsule medially and the white substance of the insula laterally. Its medial surface is concave. Its lateral surface is convex and irregular and adapted to the gyri and sulci of the insula. It is narrow above ; but broad below, where it is continuous with the anterior perforated substance and amygdaloid nucleus.

The **amygdaloid nucleus** is an ovoid mass of grey substance which lies in the wall of the anterior end of the inferior cornu of the lateral ventricle and also in the adjoining part of the roof of the inferior cornu. Above it is continuous with the putamen and below with the tail of the caudate nucleus.

The **internal capsule** (Fig. 271) is a broad band of white substance lying between the lentiform nucleus laterally and the caudate nucleus and thalamus medially. It establishes very important connections between the cerebral cortex, the basal ganglia, the nuclei of the cerebral nerves, and the medulla spinalis. It presents different appearances according to the plane in which the section of the brain is made. In horizontal section it presents a curvature; the prominence of the curve is called the *genu*, the convexity of which projects between the caudate nucleus and the thalamus. The part in front of the genu is called the frontal part; the part behind the genu is called the occipital part, of the internal capsule. The *frontal part* or *anterior limb* of the internal capsule forms about one third of the entire capsule and its direction is forwards and lateralwards. It is situated between the caudate nucleus and the front part of the lentiform nucleus. It contains: (1) fibres passing upwards from the thalamus to the frontal lobe, the *thalamofrontal fibres*; (2) fibres connecting the lentiform and caudate nuclei; (3) fibres connecting the cortex with the corpus striatum; and (4) *frontopontine fibres* which pass from the frontal lobe through the medial fifth of the base of the cerebral peduncle to the nuclei pontis. The genu contains fibres which arise from the motor area of the cerebral cortex and are called the *geniculate fibres*; these fibres pass through the base of the cerebral peduncle, undergo decussation and terminate in the motor nuclei of the cerebral nerves of the opposite side. The anterior two-thirds of the *occipital part* or *posterior limb* of the internal capsule contain *cerebrospinal fibres* which originate from the motor area of the cerebral cortex and pass downwards through the middle three-fifths of the base of the cerebral peduncle; these fibres are then continued through the pons into the pyramids of the medulla oblongata—the cerebrospinal fires are thus corticifugal fibres, representing the pyramidal or motor fibres. The posterior third of the occipital part of the internal capsule contains: (1) sensory fibres from the thalamus and some sensory fibres direct from the medial lemniscus; (2) the fibres of optic radiation from the lower visual centres (the pulvinar, lateral geniculate body and superior colliculus) to the cortex of the occipital lobe; (3) fibres of acoustic radiation from the medial geniculate body and inferior colliculus to the cortex of the temporal lobe; (4) fibres which pass from the cortex of the occipital and temporal lobes through the crusta to the pons where they end in the nuclei pontis If the fibres of the internal capsule are traced upwards they are seen to diverge and radiate to all parts of the cortex of the brain forming the *corona radiata*, the fibres of which, as has been already stated, are intersected by those of the radiatio corporis callosi. The fibres of the frontal part of the internal capsule are chiefly connected with the cortex of the frontal lobe; those of the genu and the anterior two-thirds of the occipital part, with the motor area of the cortex; those of the posterior third of the occipital part, with the parietal, temporal, and occipital regions of the cortex. Traced below the fibres of the internal capsule are continuous with the base of the cerebral peduncle.

The **external capsule** is a thin lamina of white substance situated between the lentiform nucleus medially and the claustrum laterally. It is continuous with the internal capsule in front, of and behind the lentifrom nucleus.

## The Structure of the Cerebral Hemispheres

Each cerebral hemisphere is composed of an external coating of grey substance called the *cerebral cortex* and an internal mass of white substance called the *medullary centre.*

**Cerebral cortex.**—The grey substance is spread over the entire surface of the cerebral hemisphere and dips into the sulci to cover their opposed surfaces and bottom. It is thicker over the summit of a gyrus than at the bottom of a sulcus. If sections of the cortex are examined, it is seen to present a stratified appearance i.e. grey and white layers alternating with each other. These layers are five in number and each layer is composed of nerve cells and medullated or nonmedullated nerve fibres imbedded in neouroglia. (1) The *molecular* or *plexiform layer* is the most superficial. Many of the cells of this layer are neuroglia cells, others are nerve cells which are of two kinds, small irregular cells or fusiform cells. The nerve fibres are the terminations of those fibres which come from the white substance of the hemisphere to the cortex. (2) The *pyramidal layer* constitutes the chief part of the cortex and is composed of pyramidal cells which are characteristic of the cerebral cortex. From the apex of each pyramidal cell a long dendrite passes to the molecular layer ; from the base of the cell a dendrite enters the medullary centre ; from each side of the body of the cell dendrites are given off—each dendrite gives off collaterals in its course. (3) The *layer of granules* consists mainly of stellate cells. In many places and in this layer, a narrow white band, called the *outer band of Baillarger,* is seen to run parallel with the cortex. This band is well marked behind the calcarine sulcus and in this region it is known as the *stria of Gennari.* (4) The *inner band of Baillarger* consists of medullated nerve fibres and in certain regions e.g. the paracentral lobule it contains large pyramidal cells called the *giant cells of Betz.* (5) The *polymorphous layer* is the deepest layer and consists of cells which have different shapes. Each cell gives off dendrites which do not enter the molecular layer ; their axons enter the medullary centre as nerve fibres.

The *nerve fibres of the cortex* are arranged in two groups, vertical and tangential. The *vertical* or *radial fibres* are arranged in radiating bundles which are the axons of the cells of the polymorphous or pyramidal layers going to the white substance or are the terminations of association, commissural and projection fibres coming to the cerebral cortex. The *tangential fibres* are arranged horizontally at different places and constitute (1) the *plexus of Exner* which lies superficial to the molecular layer ; (2) the *band of Bechterew* which lies superficial to the pyramidal layer ; (3) the outer band of Baillarger ; (4) the inner band of Baillarger which lies between the pyramidal and polymorphous layers.

**Medullary centre.**—The white substance of the cerebral hemisphere consists of medullated nerve fibres, which according to their courses and connections are arranged into three distinct groups viz. commissural fibres, association fibres, and projection fibres.

The **commissural fibres** are disposed transversely and connect together portions of cerebral cortex of opposite hemispheres. They constitute three definite structures : (1) the corpus callosum, (2) the anterior commissure, (3) the posterior commissure, (4) the hippocampal commissure. These structures have already been described. The *fibres of the corpus callosum* spread out in an extensive radiation so that practically every part of the cerebral hemisphere is reached by these fibres and they serve to connect the cortex of one hemisphere with that of the other. But these callosal fibres do not connect symmetrical portions of the cortex always but dissimilar portions become connected with each other on account of the extensive scattering of those fibres. The *anterior commissure* crosses from side to side and connects together the two olfactory bulbs and also portions of the opposite temporal lobes. The fibres of the *posterior commissure* arise from a nucleus in the grey substance of the upper end of the cerebral aqueduct, cross the median plane and descend in the tegmentum of the cerebral peduncle. The *hippocampal commissure* connects the hippocampus of one side with its fellow of the opposite side.

The **association fibres** serve to connect different parts of the cortex of the same hemisphere and are of two kinds, short and long. The *short association fibres* pass between adjacent gyri and curve round the bottoms of the sulci. The *long association fibres* pass between portions of grey cortex which are far removed from each other. They are arranged in bundles and the better known of these are : (1) the superior longitudinal fasciculus, (2) the inferior longitudinal fasciculus, (3) the cingulum, (4) the uncinate fasciculus, (5) the occipitofrontal fasciculus, (6) the perpendicular fasciculus, and (7) the fornix.

The *superior longitudinal fasciculus* is placed on the basal aspect of the corona radiata and connects the frontal and occipital lobes ; some of its fibres sweep downwards and forwards into the lobe and on account of this, it is called the *arcuate fasciculus*. The *inferior longitudinal fasciculus* extends along the whole length of the occipital and temporal lobes. The *cingulum* is a conspicuous band ; it begins in the region of the anterior perforated substance, proceeds forwards and upwards above the rostrum and then turns round the genu ; it next proceeds backwards over the body of the corpus callosum and, winding round the splenium, terminates posteriorly in the hippocampal gyrus. Thus, its fibres connect the gyri of the limbic lobe with the cerebral cortex. The *uncinate fasciculus* arches over the stem of the lateral cerebral fissure and connects the frontal and temporal lobes. The *occipitofrontal fasciculus* connects the frontal with the occipital and temporal lobes. Its fibres lie on the medial aspect of the corona radiata in intimate relation to the caudate nucleus; posteriorly the fibres radiate in a fan-like manner over the superior and lateral aspects of the lateral ventricle where they constitute the tapetum—it is believed that the fibres of the tapetum are not derived from the corpus callosum but from this fasciculus. The *fornix* connects the hippocampal gyrus of one side with the corresponding corpus mamillare and through the corpus with the optic thalamus by means of the mamillothalamic fasciculus.

The **projection fibres** connect the cerebral cortex with parts at a lower level of the brain and with the medulla spinalis. They are grouped into two kinds, efferent and afferent, and constitute well-marked tracts. The chief efferent tracts are: (1) the corticopontine fibres which end in the nuclei of the pons; (2) the cerebrospinal fibres which pass through the pyramid of the medulla oblongata into the spinal medulla; (3) the geniculate fibres which decussate and terminate in the motor nuclei of cerebral nerves of the opposite side—the last two constitute the motor tract occupying the anterior two-thirds of the occipital part of the internal capsule and the genu. The afferent fibres belong to the following tracts: (1) brachium conjunctivum, (2) mesial fillet, (3) thalamic radiation, (4) optic radiation, (5) auditory radiation.

## THE FUNCTIONAL AREAS OF CEREBRAL CORTEX

The definitely known areas of the specific functions of the cerebral cortex are:—(1) The *motor area* is the area in which arise most of the cerebral motor fibres for the cortical control of the general muscular system. The muscles of the tongue, larynx, pharynx and of mastication are controlled from the frontal operculum; of the head and neck from the middle frontal gyrus; of the trunk, from the upper portion of the anterior central gyrus; of the lower limb, from the highest portion, and of the upper limb from the middle portion of the anterior central gyrus. (2) The *visual area* is known as the area striata of the occipital cortex (Gennari) which presents a distinct white line or stria on section. (3) The *auditory area* comprises the middle third of the superior temporal gyrus and the adjacent gyri on the lateral cerebral hemisphere. (4) The *olfactory area* is the rhinencephalon. (5) The *gustatory area* comprises the hippocampal gyrus and the uncus. (6) The *associational areas* are three: (*a*) the pre-frontal, (*b*) the posterior portions of the parietal and temporal lobes, (*c*) the insula.

### The Motor Tracts (Figs. 272, 273).

The motor tracts are included under two groups: (1) the cortical group which is associated with voluntary movements—the strands of this group originate from the cells of the cerebral cortex; (2) the subcortical group which is associated with involuntary movements—the strands of this group originate from the cells of the basal ganglia of the brain.

**Cortical group.** The cortical motor strands are subdivided into corticocerebral and corticospinal tracts. The **corticocerebral motor tracts** begin as the axis cylinder processes of the cells of Betz situated in the motor area of the cerebral cortex. The fibres converge as they descend to occupy the middle segment of the corona radiata and pass between the lentiform nucleus and caudate nucleus in the genu of the internal capsule—the fibres in the genu are called geniculate fibres. The fibres next traverse (1) the medial part of the base of the cerebral peduncle, then reach (2) the pons and then (3) the medulla oblongata. As the main strand proceeds downwards, fibres intended for the cerebral motor nerves (1) leave the strand in each of the three above mentioned regions of the brain, (2) cross the middle line, (3) decussate with similar fibres of the opposite side, and (4) terminate in the subcortical ganglia of the motor cerebral nerves.

The **corticospinal motor tracts** are subdivided into two groups: a principal and a secondary.

The **principal motor tracts** aise from the cells of Betz in the motor area of the cerebral cortex. The fibres descend to occupy (1) the middle segment of the corona radiata and then traversing (2) the anterior two-thirds of the occipital part of the internal capsule behind the geniculate fibres proceed through (3) the middle three-fifths of the base of the cerebral peduncle into the ventral aspects of (4) the pons and (5) the medulla oblongata. At the medulla the strand divides into three groups of fibres:—(1) Those situated near the anteromedian fissure and constituting about the medial three-fourths of the fibres decussate at the bottom of the fissure with similar fibres from the opposite side and form what is known as the **decussation of the pyramids.** These fibres then descend in the lateral funiculus of the opposite side as the lateral cerebrospinal fasciculus(crossed pyramidal tract) and ultimately end around the nerve cells in the posterior column of grey substance of the medulla spinalis at varying levels. (2) Of the lateral one-fourth of the fibres, most of them descend in the anterior funiculus of the same side of the medulla spinalis as the anterior cerebrospinal fasciculus (direct pyramidal tract); the fibres of this tract eventually cross in the anterior white commissure at varying levels to end in the grey matter of the opposite side of the medulla spinalis. (3) A smaller number of fibres of the second group form the uncrossed lateral cerebrospinal fibres and issuing from the cerebral cortex of the same side terminate in the same side of the medulla spinalis.

The **secondary corticospinal motor tracts** comprise the corticocerebellar spinal fibres; they arise from the cells in the same areas as the cells of the principal motor tracts—their fibres descend with the principal motor tract, through the internal capsule and cerebral peduncles to the pons where they quit the principal tract and end in the nerve cells of the nucleus pontis forming the corticopontine tracts. The axis cylinders of the cells of this nucleus cross over to the opposite half of the cerebellum and end in the neurons of the cerebellar cortex which convey impulses through the cells of Deiter's nucleus to the medulla spinalis and thence to the grey substance of the anterior cornu and eventually to the muscles.

**Subcortical group.**—The subcortical motor strands arise in the cells of the basal ganglia of the brain, proceed by successive neurons downwards and eventually reach and arborize round the motor cells of the cerebral nerve nuclei or of the anterior grey column of the medulla spinalis. The chief subcortical motor tracts are :—(1) the *striospinal,* from the cells of the globus pallidus ; (2) the *rubrospinal,* from the cells of the red nucleus of the opposite side ; (3) the *tectospinal,* from the corpora quadrigemina ; (4) the *vestibulospinal,* from the accessory nucleus of Deiters in the pons ; (5) the *pontospinal,* from the cells in the formatio reticularis.

### The Sensory Tracts (Figs. 272, 273).

The sensory tracts convey impulses from the periphery to the brain. Each strand possesses a peripheral and a central set of neurons. The peripheral neurons are uncrossed and single and their cells are situated in the ganglia of the sensory nerves in the case of cerebral nerves and in the spinal ganglia in the case of spinal nerves. The cells of these ganglia possess (1) a peripheral process, by which the cells are brought in communication with the surface of the body, and (2) a central process by which the cells are connected with the central axis. The central neurons serve as the bond of connection between the higher nerve centres and the peripheral neurons and are situated within the central nerve axis. They are crossed –the crossing takes place either in the medulla spinalis or in the medulla oblongata or at higher levels. The chief sensory strands in the medulla spinalis are :—

(1) **Fasciculi gracilis and cuneatus.**—The fasciculi gracilis and cuneatus end in their respective nuclei in the medulla oblongata. From these nuclei fibres pass by either of these two paths,—(*a*) through the restiform body to the cerebellum of the same or of the opposite side ; or (*b*) through the medulla oblongata where they (i) cross the middle line, (ii) decussate with similar fibres from the opposite side forming the sensory decussation, (iii) pass through the pons, the cerebral peduncles and the posterior third of the occipital part of the internal capsule to end in the cerebral hemisphere of the opposite side. The majority of these fibres as they pass through the thalamus end in it ; from the thalamus fresh fibres begin to terminate at the cerebral cortex ; some of these fibres however pass direct to the cerebral cortex without undergoing interruption at the thalamus.

(2) The **superficial antrolateral fasciculus** (tract of Gowers) is composed of three strands of fibres,—(*a*) the *anterior spino-*

*cerebellar fibres* pass upwards to the pons at the level of the trigeminal nerve nucleus and then turning downwards and backwards through the brachium conjunctivum end in the vermis of the cerebellum; (*b*) the *spinotectal fibres* end in the corpora quadrigemina; and (*c*) the *spinothalamic fibres* pass through the occipital part of the internal capsule to the thalamus and to the cerebral cortex; these carry sensations of touch, of pain, and of temperature from the posterior spinal nerve roots of the opposite side.

(3) The **direct cerebellar tract** passes through the restiform body to end in the vermis of the cerebellum. This tract is associated with the coordination of muscular movements.

The chief sensory strand in the brain is the lemniscus or fillet.

The **lemniscus** is the strand of fibres carrying sensory impulses from the posterior spinal nerve roots, the nuclei of the auditory nerve and the sensory nuclei of the cerebral nerves. The lemniscus is divisible into two portions, medial and lateral.

The *medial lemniscus* is the upward continuation of the fasciculi gracilis and cuneatus through their respective nuclei. These fibres decussate in the medulla oblongata with similar fibres from the opposite side and constitute the decussation of the lemniscus or *sensory decussation;* the fibres then pass through the dorsal part of the medulla oblongata, pons and cerebral peduncles and ultimately being reinforced by fibres from the sensory nuclei of the cerebral nerves end in the thalamus; a new set of fibres called the thalamocortical fibres, begin from the thalamus and pass through the posterior one-third of the occipital part of the internal capsule to the cerebral cortex.

The *lateral lemniscus* is the upward continuation of the fibres from the terminal cochlear nerve nuclei, also of fibres from the superior olivary and trapezoid nuclei. The fibres end in the inferior colliculus and the medial geniculate body. From these fresh fibres arise to end in the cortical centre for hearing viz. the superior temporal gyrus.

## The Base of the Brain

The inferior aspect of the brain is called the **base of the brain** (Fig. 254). It presents for examination the following parts:—(1) the anterior end of the longitudinal fissure; (2) the inferior surface of the frontal lobe on either side of the longitudinal fissure together with the olfactory tract and bulb; (3) the rostrum or anterior terminal part of the corpus callosum; (4) the lamina terminalis; (5) the optic chiasma and the optic tracts; (6) the anterior perforated substance; (7) the tuber cinereum; (8) the infundibulum and the hypophysis; (9) the corpora mamillaria; (10) the posterior perforated substance; (11) the inferior surfaces of the temporal lobes; (12) the peduncles of the cerebrum; (13) the anterior surfaces of the pons and the medulla oblongata; (14) the inferior surface of the cerebellum; (15) the superficial attachments of the cerebral nerves.

The **lamina terminalis** (lamina cinerea) will be seen if the

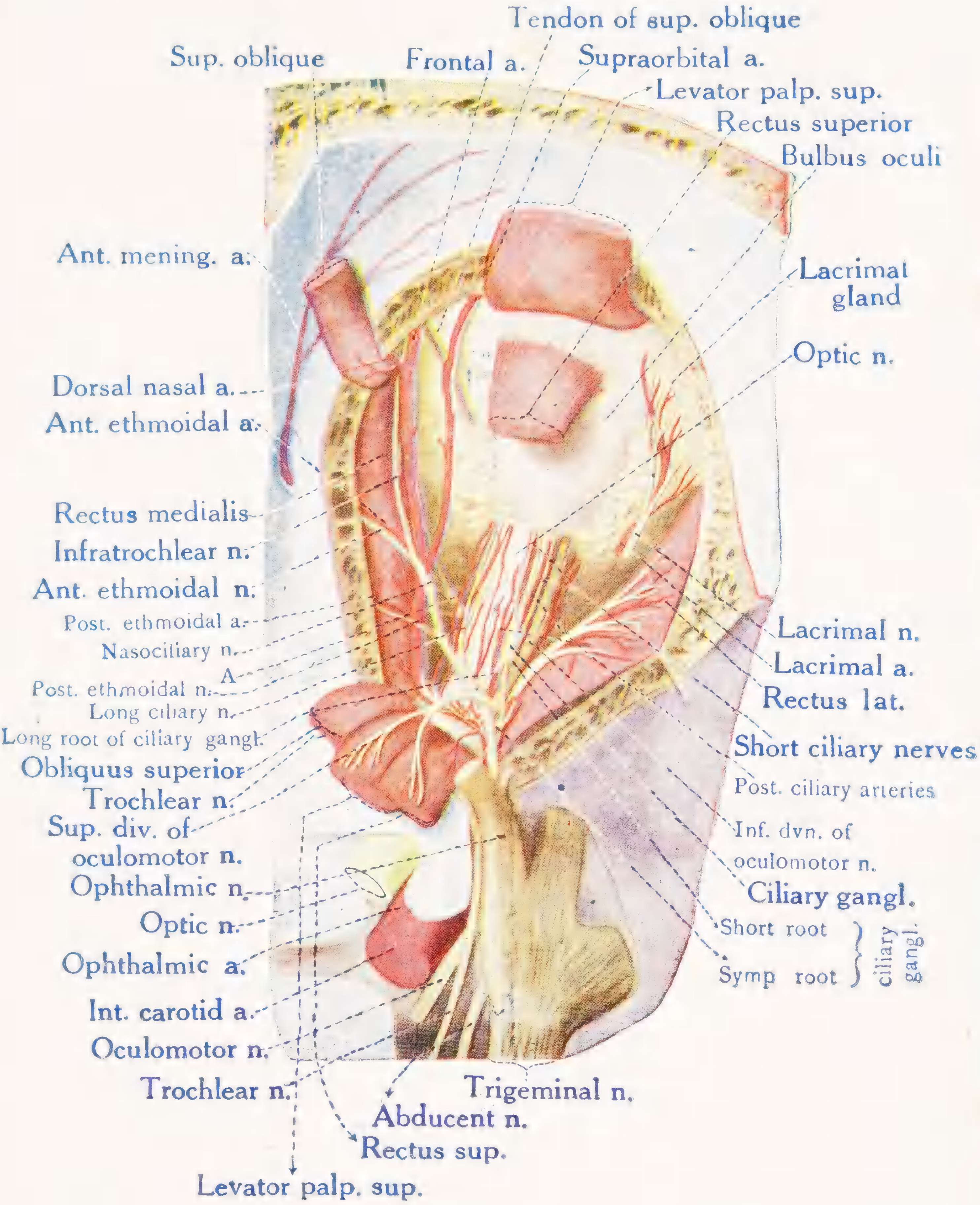


Fig. 275. – The dissection of the orbit.

(See p. 555).

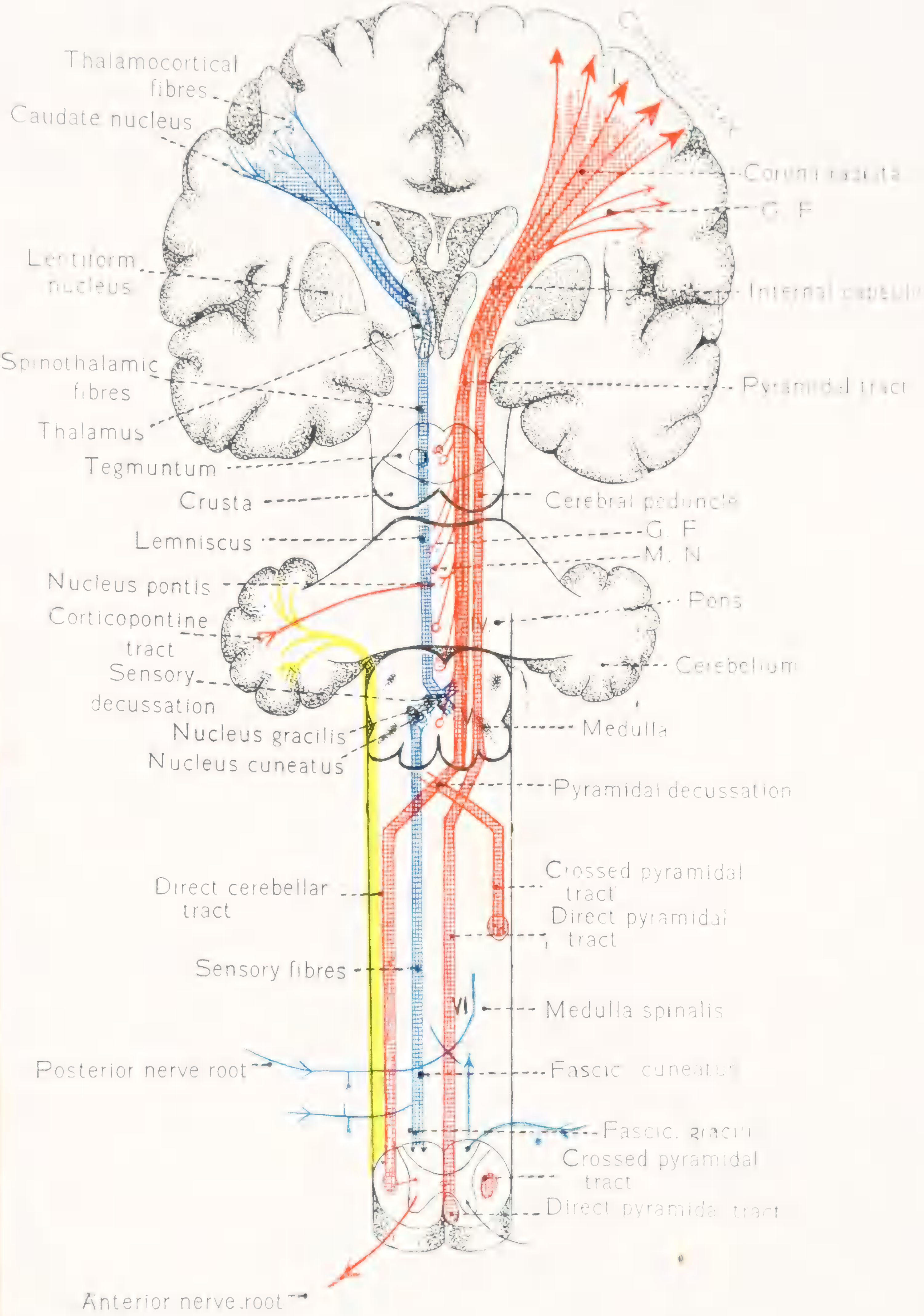


Fig. 272.—The motor and sensory tracts. G. F.—Geniculate fibres ending in cerebral motor nuclei. M. N.—Motor nuclei of 3rd, 4th, 5th, 6th, 7th, 9th, 10th, 11th and 12th cerebral nerves.

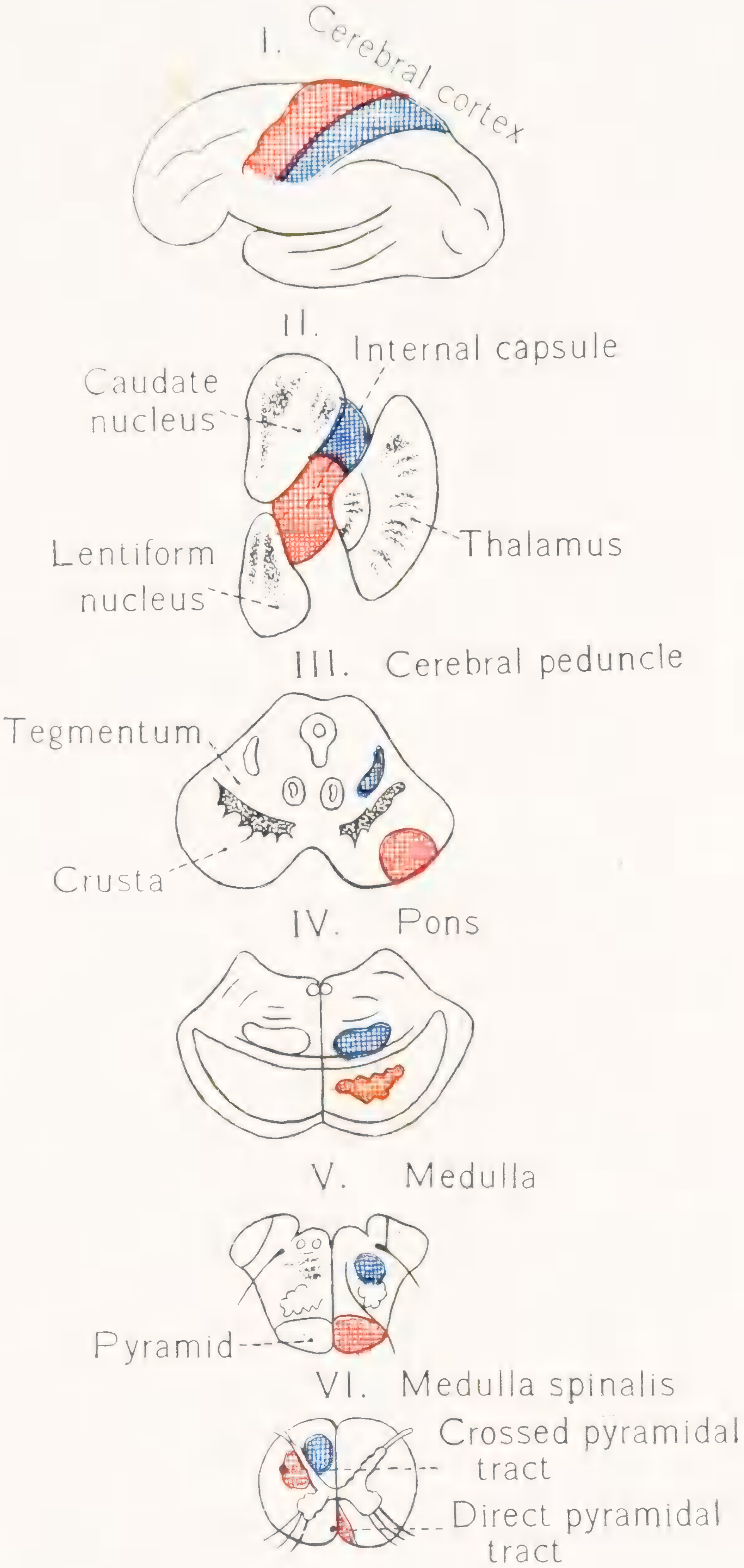


Fig. 273.—Figures I to VI show the successive positions of the motor and sensory tracts in the brain and medulla spinalis. The motor areas are coloured red and sensory areas blue.

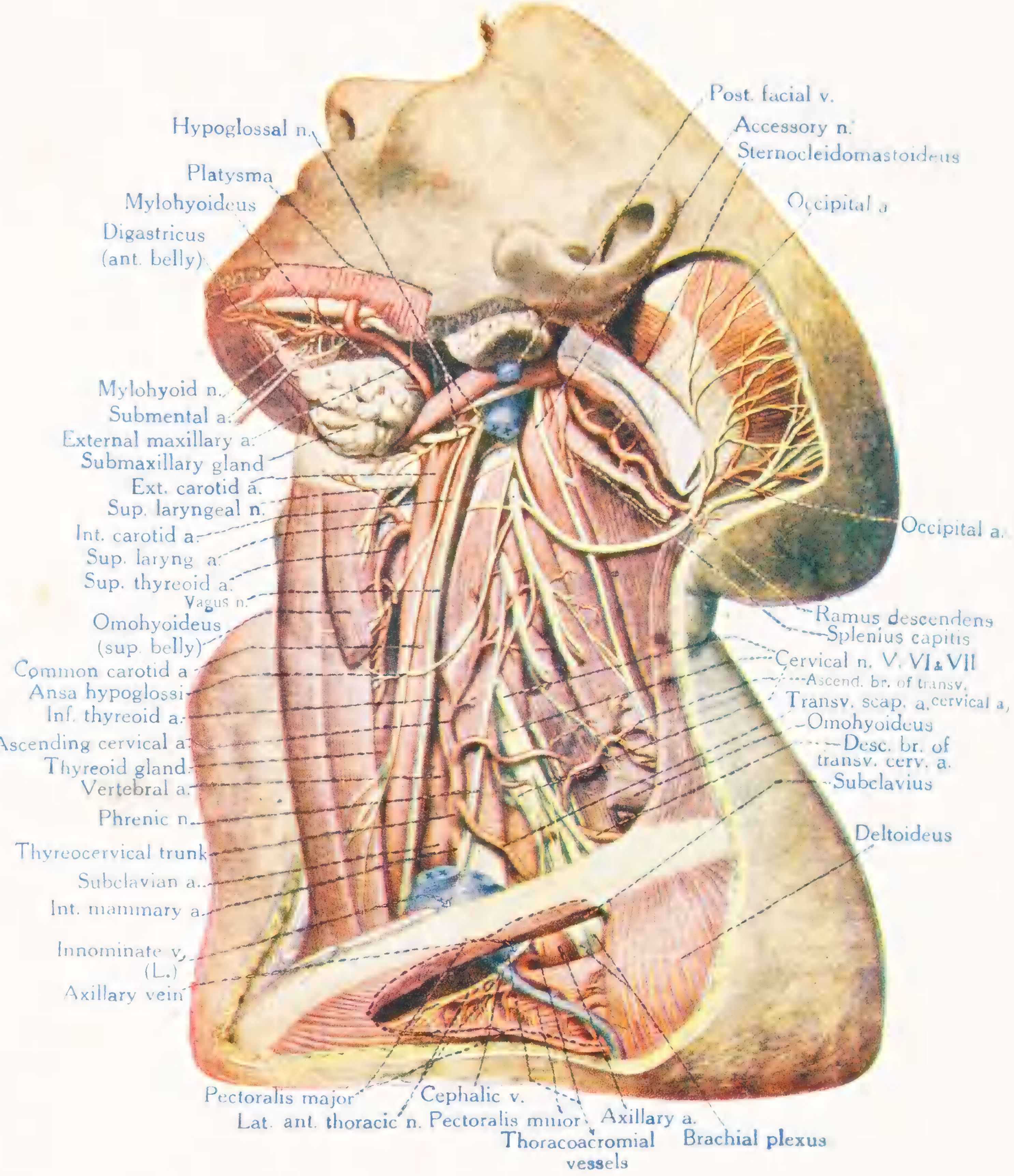


Fig. 278.—Deep dissection of the neck.

(See p. 575)

hemispheres are gently separated from each other and the optic chiasma is drawn backwards. It is a thin layer of grey substance which passes downwards and backwards from the rostrum of the corpus callosum to the upper surface of the optic chiasma.

The **interpeduncular fossa** is a lozenge-shaped space bounded anteriorly by the optic chiasma, antero-laterally by the optic tracts, posteriorly by the pons, and postero-laterally by the cerebral peduncles. This space corresponds to the floor of the ventricle and contains the following structures from before backwards:—the tuber cinereum with infundibulum, hypophysis, corpora mamillaria, the posterior perforated substance, and the oculomotor nerves.

The **tuber cinereum** is a slight eminence of grey substance placed immediately behind the optic chiasma and between the optic tracts.

The **infundibulum** is a hollow conical process which projects downwards from the tuber cinereum and becomes attached to the posterior lobe of the hypophysis.

The **posterior perforated substance** (posterior perforated space) is composed of grey substance and is so called on account of its being perforated by numerous small apertures for the passage of vessels, viz., the posteromedial ganglionic arteries. It is situated between the corpora mamillaria in front and the diverging cerebral peduncles behind.

**Superficial attachments of the cerebral nerves.**—The *olfactory nerves* are attached to the olfactory bulb. The *optic nerve* joins the antero-lateral angle of the optic chiasma. The *oculomotor nerve* is attached to a groove, called the oculomotor sulcus, on the medial aspect of the cerebral peduncles. The *trochlear nerve* is attached to the dorsal aspect of the midbrain behind the corpora quadrigemina. It winds round the lateral side of the cerebral peduncle to reach the base of the brain. The *trigeminal nerve* consists of a large sensory root and a small motor root. Both are attached to the ventral surface of the pons near its upper border. The motor root lies in front of and medial to the sensory root at the sites of their attachments. The *abducent nerve* is attached to the groove between the lower border of the pons and the upper end of the pyramid of the medulla oblongata. The *facial* (consisting of motor and sensory parts) and *acoustic* (consisting of ventral and dorsal roots) *nerves* are attached to the groove below the lateral part of the lower border of the pons; the former nerve lying medial to the latter. The *glossopharyngeal, vagus* and *accessory nerves* are attached in a continuous line by filaments to the posterolateral sulcus of the medulla oblongata. The spinal part of the accessory nerve is derived from the medulla spinalis. The *hypoglossal nerve* is attached by many filaments to the anterolateral sulcus of the medulla oblongata.

## The Meninges of the Brain and Medulla Spinalis

The brain and medulla spinalis are enclosed within three membranes, collectively called the meninges. The membranes protect and support the organs and are named from without inwards: the dura mater, the arachnoid, and the pia mater.

The **cerebral dura mater** performs a double function—it acts as an internal periosteum for the bones which it lines and it forms a protective covering for the organ. Its outer surface is rough and firmly adherent to the inner surfaces of the skull bones specially along the lines of the sutures; this rough appearance is due to the numerous fibrous processes and blood vessels which pass between the dura mater and cranial bones. Its inner surface is smooth and free and is separated from the arachnoid by an interval called the *subdural space*. This space contains a little serous fluid enough to lubricate the opposed surfaces of the two membranes. The cerebral dura mater consists in reality of two layers an outer or *endosteal layer* which lines the inner surfaces of the cranial bones serving as an internal periosteum; and an inner or *meningeal layer* which protects the brain giving off *processes* between the different parts of the brain for their support; these two layers are intimately blended together except in some places where they separate and form venous channels called *sinuses*. It is most intimately adherent to the bones at the base of the skull and around the foramen magnum. At the foramen magnum its inner layer becomes continuous with the dura mater of the medulla spinalis. It furnishes sheaths to the cerebral nerves as they pass through the several foramina—its outer layer becomes continuous with the pericranium outside the foramina.

**Processes of the dura mater** (Fig. 244).—The dura mater gives off four processes—two vertical viz., the falx cerebri and falx cerebelli; and two horizontal viz., the tentorium cerebelli and diaphragma sellæ. All of them are formed by reduplication of its meningeal layer.

The **falx cerebri** is a sickle-shaped process of the dura mater formed by the reduplication of its inner meningeal layer. It dips in vertically between the cerebral hemispheres. In front it is attached to the crista galli of the ethmoid by its narrow extremity. Behind it is broad and is attached to the upper surface of the tentorium cerebelli where it splits and forms with the tentorium a venous passage called the straight sinus. Its upper margin is convex and attached to the middle line of the vertex of the skull as far back as the internal occipital protuberance; it splits to enclose the superior sagittal sinus. Its lower margin is concave and free and contains the inferior sagittal sinus.

The **falx cerebelli** is a triangular process of the dura mater given off between the hemispheres of the cerebellum. Its base is uppermost being attached to the inferior surface of the tentorium cerebelli at its back part. Its apex divides into two narrow processes which are continued to the sides of the foramen magnum. Its posterior border is convex and is attached to the internal occipital crest and encloses the occipital sinus. Its anterior border is free and lies in the cleft between the two cerebellar hemispheres.

The **tentorium cerebelli** is an arched process of the dura mater interposed between the cerebellum below and the posterior part of the cerebrum above. When observed in situ it is almost horizontal, elevated in the centre and gradually sloping down towards the circumferential attachment. Its posterior border or the circumferential attached part is convex and is attached behind to the margins of the transverse sulci on the inner surface of the occipital bone and to the margins of the groove at the inner aspect of the mastoid angle of the parietal bone ; at this attachment it splits to enclose the transverse sinus ; further in front it is attached to the superior border of the petrous portion of the temporal bone and here it splits to enclose the superior petrosal sinus. The anterior border is free and concave. At the apex of the petrous portion of the temporal bone the anterior and posterior borders meet and cross each other and are prolonged forwards to be attached respectively to the anterior and posterior clinoid process of the sphenoidal bone. Its superior surface is convex and gives attachment to the falx cerebri in the middle line antero-posteriorly ; the straight sinus runs along the junction of these two processes of the dura mater. Its inferior surface gives attachment posteriorly to the base of the falx cerebelli.

The **diaphragma sellae** is a circular horizontal fold which retains the hypophysis in the sella turcica. It presents a small opening in the centre through which the infundibulum passes.

The *arterial supply* of the cerebral dura mater is derived from the meningeal arteries which ramify in its outer layer. In the anterior cranial fossa the meningeal branches are derived from the anterior and posterior ethmoidal and internal carotid arteries; in the middle cranial fossa are the middle meningeal and accessory meningeal arteries and meningeal branch of the ascending pharyngeal artery ; in the posterior cranial fossa are the meningeal branches of the ascending pharyngeal, occipital and vertebral arteries. The *meningeal veins* communicate with the diploic veins and end either directly into the intracranial venous sinuses or indirectly through the venous lacunæ. The *nerves* are derived from the sympathetic, the three divisions of the trigeminal, the vagus and hypoglossal.

The **spinal dura mater** (Fig. 250) corresponds to the meningeal layer of the cranial dura mater. The endosteal layer of the cranial dura mater is continued down into the vertebral canal as the periosteum lining the bones which bound the canal. The space between the wall of the vertebral canal and spinal dura mater is called *epidural space* and contains areolar tissue and plexuses of veins. The venous plexuses on the surface of the spinal dura mater correspond to the sinuses of the dura mater inside the cranium. Above the spinal dura mater is attached to the margin of the foramen magnum. Below it extends as far as the lower margin of the second sacral vertebra. Here it is suddenly narrowed and prolonged as an adherent sheath of the filum terminale which is a thread-like structure continued from the termination of the medulla spinalis. As a sheath of the filum terminale it is prolonged over the back part of the coccyx where it blends with the periosteum covering that bone. Laterally it is prolonged as sheaths on the spinal nerves which pierce it. It presents two bulgings, one in the cervical region and the other in the lumbar region. Its *inner surface* is smooth and glistening. It is separated from the arachnoid by a capillary space called the *subdural cavity*. Laterally corresponding to each spinal nerve there are two openings in the dura mater, one for the anterior and the other for the posterior root. The spinal dura mater differs from the cerebral dura mater in (1) being destitute of the endosteal layer ; (2) not containing venous sinuses; (3) not sending processes into the medulla spinalis.

The *arteries* of the spinal dura mater are derived from the vertebral, intercostal, lumbar and lateral sacral arteries. The *nerves* are derived from the spinal and sympathetic nerves.

The **cerebral arachnoid** is an exceedingly thin membrane covering the whole of the brain. It is placed over the pia mater which it closely invests, except over the base of the brain —over this region the arachnoid can be properly demonstrated because here it is not only thick but is also separated from the subjacent pia mater by a considerable interval. Unlike the pia mater it does not dip into the fissures and sulci of the brain (except into the longitudinal fissure) but bridges over them. It is separated from the dura mater by a capillary space called called the *subdural space* which contains fluid of the nature of lymph. It is separated from the subjacent pia mater by an interval, called the *subarachnoid cavity*, which contains cerebrospinal fluid and is traversed by trabeculæ of connective tissue passing from the arachnoid to the pia mater. The subarachnoid cavity of the brain is continuous with the subarachnoid cavity of the medulla spinalis and communicates with the ventricles of the brain. Over the lateral surface of the hemispheres the subarachnoid cavity is insignificant but in certain situations at the base of the brain the arachnoid is separated from the pia mater by deep and wide intervals called subarachnoid cisternæ.

**Subarachnoid cisternæ.**—These are :—(1) The *cisterna cerebellomedullaris* (cisterna magna) is formed by the arachnoid bridging over the space between the medulla oblongata and the back part of the under surface of the cerebellum. (2) The *cisterna pontis* is seen on the ventral aspect of the pons where the arachnoid covers the basilar artery. (3) The *cisterna interpeduncularis* (cisterna basalis) lies in front of the pons where the arachnoid extends from the temporal lobe of one side to that of the other side ; it contains the arteries of the circulus arteriosus. (4) The *cisterna chiasmatis* lies in front of the optic chiasma and contains the anterior cerebral arteries. (5) The *cisterna fossae cerebri lateralis* is formed over the lateral fissures of the brain by the arachnoid bridging over the fissure between the temporal lobe, and the frontal and parietal lobes. (6) The *cisterna venae magnae cerebri,* is formed by the arachnoid bridging over the gap between the posterior end of the corpus callosum and the superior surface of the cerebellum ; it contains the great cerebral vein.

The **arachnoideal granulations** (glandulæ Pacchionii) are small granular masses seen on either side of the middle line of the outer surface of the dura mater. These granulations are the outgrowths of the arachnoideal trabeculæ which have pushed and stretched the dura mater before them. They produce indentations on the inner surface of the skull cap on either side of the sagittal suture. They are usually seen after the seventh year and are conspicuous in old age.

The **spinal arachnoid** is a very thin delicate membrane and surrounds the medulla spinalis loosely. It is continuous above with the arachnoid of the brain. The loose sheath is largest below where it covers the lumbar enlargement of the medulla spinalis and the bunch of nerves prolonged downwards forming the cauda equina. Laterally it is prolonged over the spinal nerve roots forming sheaths for them. The spinal part of the *subarachnoid cavity* is a wide interval between the arachnoid and the pia mater and contains cerebrospinal fluid and is continuous above with the cranial subarachnoid cavity. The cavity is largest below where the arachnoid encloses the nerves constituting the cauda equina The cavity is imperfectly subdivided into three compartments by three septa, one posterior and two lateral. The posterior septum is called the *subarachnoid septum* (septum posticum) and connects the inner surface of the arachnoid with the pia mater over the posterior surface of the medulla spinalis. The lateral septa are called the ligamenta denticulata. The subarachnoid cavity has no communication with the subdural cavity.

The **cerebral pia mater** is the vascular membrane of the organ. In it the blood vessels ramify and from its deep surface minute arterial twigs enter the substance of the brain. It gives off sheaths to these numerous minute vessels as they enter the brain substance. It also gives off sheaths to the cerebral nerves as they pass out. It dips into the fissures and sulci of the cerebrum and cerebellum. On the surface of the cerebellum it is thinner and less vascular. It is prolonged into the interior of the brain forming the tela chorioidea of the third ventricle and the chorioid plexuses of the lateral and third ventricles. Over the lower part of the roof of the fourth ventricle it forms the tela chorioidea and chorioid plexuses of the fourth ventricle. There are three openings in the pia mater through which the subarachnoid cavity communicates with the ventricles of the brain. One is called the *foramen of Majendie* and is situated in the middle line over the inferior angle of the roof of the fourth ventricle. The other two apertures are laterally placed over the ends of the lateral recesses of the fourth ventricle.

The **spinal pia mater** is closely adherent to the entire surface of the medulla spinalis. It is less vascular but thicker than the cerebral pia mater. It consists of two layers between which the blood vessels of the medulla spinalis ramify before they enter its substance. Above it is continuous with the pia mater covering the brain. Below where the medulla spinalis ends it gradually contracts and is continued downwards through the centre of the cauda equina as an investment of the filum terminale. Anteriorly, in the median plane, it is thickened to form a longitudinal glistening band. called the *linea splendens.* Laterally it is thickened into a longitudinal band, called the *ligamentum denticulatum,* and is prolonged on the spinal nerves as sheaths for them.

The **ligamentum denticulatum** is a band of pia mater which extends on each side of the medulla spinalis. Its medial margin is attached in a continuous line between the anterior and posterior nerve roots. Its lateral margin is denticulated. The denticulations, twenty one in number, push the arachnoid before them and are attached by their pointed outer ends to the inner surface of the dura mater. The ligamenta denticulata act as lateral supports to the medulla spinalis.

## THE CEREBRAL NERVES

The cerebral nerves are arranged in twelve pairs. They have numerical as well as descriptive names. From before backwards they are as follows :

| | | | |
|---|---|---|---|
| First. | Olfactory. | Seventh. | Facial. |
| Second. | Optic. | Eighth. | Acoustic. |
| Third. | Oculomotor. | Ninth. | Glossopharyngeal. |
| Fourth. | Trochlear. | Tenth. | Vagus. |
| Fifth. | Trigeminal. | Eleventh. | Accessory. |
| Sixth. | Abducent. | Twelfth. | Hypoglossal. |

A thirteenth pair of cerebral nerves has been described. This pair, called the *nervi terminales,* is associated with the olfactory nerves. Each nervus terminalis is attached to the anterior perforated substance posterior to the medial olfactory stria and runs with the corresponding olfactory tract on its medial side to be distributed to the nasal mucous membrane like the olfactory nerve filaments.

Each cerebral nerve makes its superficial appearance at a at a particular area on the surface of the brain and becomes attached here constituting the *superficial origin* of the nerve. In the case of motor nerves they really issue out of the brain at the areas of superficial origins whereas in the case of sensory nerves they really enter the brain at those areas to gain its interior. Strictly speaking therefore, the superficial origin should be called the *superficial attachment* of a cerebral nerve. If these nerves are traced from their superficial attachments to the substance of the brain they are found to be connected with nuclei of grey substance in the interior of the brain. These nuclei are called the *nuclei of origin* in the case of motor nerves and the *nuclei of termination* in the case of the sensory nerves.

## The Olfactory Nerves

The **olfactory nerves** (Fig. 274) are the nerves of smell. They consist of about twenty filaments and are nonmedullated. They arise from the olfactory cells and are in fact the processes of the cells in the olfactory region of the nasal cavity—this region comprises the upper third of the nasal septum and the whole of the superior nasal concha. On the mucous membrane of this region the nerve fibres form plexuses from which about twenty filaments issue on each side and pass through the lamina cribrosa of the ethmoid and end by arborizing in the glomeruli of the olfactory bulb. Each filament is provided with a sheath of dura mater and of pia mater. The olfactory centre is associated with the rhinencephalon which is often designated as the olfactory brain.

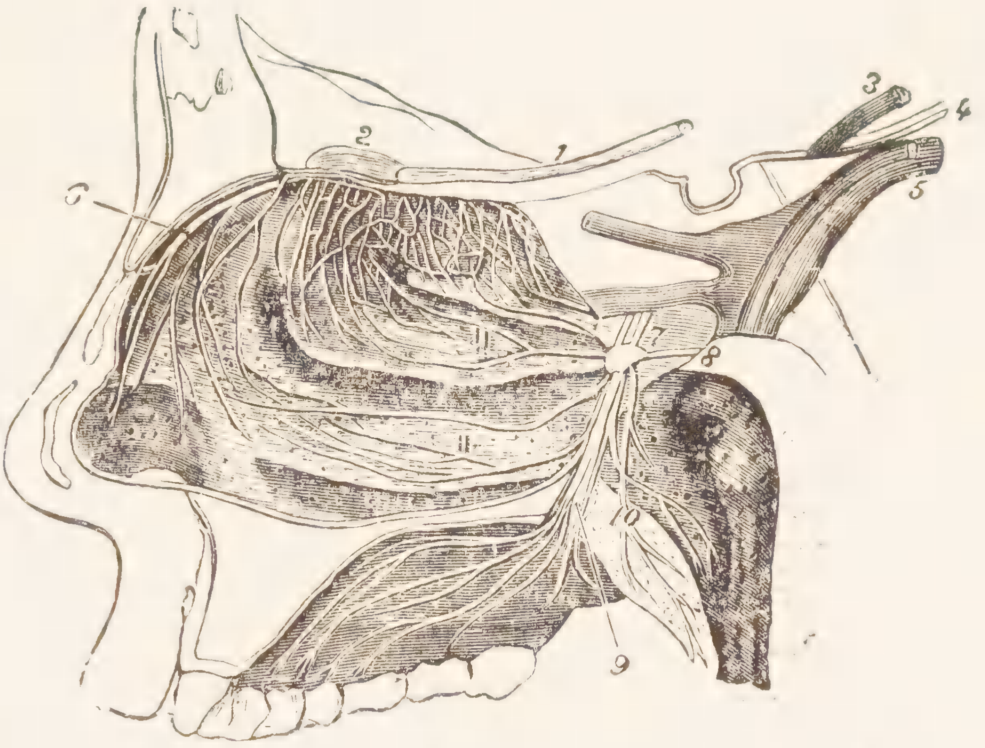


Fig. 274.—The nerves of the lateral wall of the nasal cavity and of the palate.

1. Olfactory tract.
2. Olfactory bulb giving branches to the nasal cavity.
3. Oculomotor nerve.
4. Trochlear nerve.
5. Trigeminal nerve.
6. Nasociliary nerve.
7. Sphenopalatine ganglion.
8. Nerve of the pterygoid canal.
9. Anterior palatine nerve.
10. Posterior palatine nerve.
11. Posterior inferior nasal branches.

## The Optic Nerve

The **optic nerve** (Fig. 275) is the nerve of sight. Its nerve fibres arise from the ganglion cells of the retina and converge to the optic papilla where they are accumulated into a bundle called the optic nerve. The nerve pierces the chorioid coat and the lamina cribrosa of the sclera about $\frac{1}{8}$ inch to the medial side of the posterior pole of the eyeball and enters the orbital fat. The *intraocular part* of the nerve is less than 1 mm. in length. Within the orbit (*intraorbital part*) it runs backwards and medialwards to the optic foramen ; here it is crossed by the opthalmic artery ; it is pierced below by the arteria centralis retinæ and vein of the retina and is surrounded by the ciliary vessels and nerves which lie in the orbital fat. It then passes through the optic foramen (*intraosseous portion*) to the middle fossa of the skull ; here it lies above the ophthalmic artery and is separated from the sphenoidal air sinus by a thin plate of bone. Within the cranium (the *intracranial part*) it runs backward and medialwards to terminate in the optic chiasma ; here it lies beneath the olfactory tract and gyrus rectus and is placed above the opthalmic artery and medial to the internal carotid artery. The optic nerve consists of medullated fibres and is surrounded by sheaths from each of the three membranes of the brain. The *optic chiasma* and the *optic tracts* have been described on p. 522.

### The Oculomotor Nerve

The **oculomotor nerve** (Fig. 275) supplies the levator palpebræ superioris, all the ocular muscles, except the rectus lateralis and obliquus superior, and also two muscles within the eyeball viz., the sphincter pupillæ and musculus ciliaris. The fibres of this nerve arise from a nucleus which is situated in the grey substance of the floor of the cerebral aqueduct in the mid-brain and extends superiorly for a short distance into the floor of the third ventricle. From this origin the fibres pass forwards through the tegmentum, the red nucleus, the inner part of the substantia nigra, and eventually make their superficial appearance at the oculomotor sulcus on the medial side of the cerebral peduncle. The nucleus of origin of the oculomotor nerve is connected, (1) with the trochlear and abducent nerve nuclei by means of the medial longitudinal bundle, and thus a co-ordinate action between all the muscles of the eyeball is maintained ; (2) with the facial nerve by fibres which pass from it through the same bundle to supply the corrugator frontalis and orbicularis oculi so that these muscles strictly speaking are innervated by the oculomotor nerve ; (3) with the occipital lobe of the cerebrum by fibres passing through the optic radiation ; (4) with the cerebellum through the brachium conjunctivum ; and (5) with the superior colliculus and thus with the optic tract. The nucleus consists of seven groups of cells on each side ; besides there is a medially placed group which supplies filaments to the oculomotor nerves of both sides. These seven groups are believed to correspond to the seven muscles supplied by the nerve, so that the fibres which arise from a particular group of cells supply a particular muscle. Moreover some fibres are derived from the nucleus of the opposite side thus giving rise to a median decussation and those crossed fibres supply the medial rectus.

From the oculomotor sulcus the nerve passes between the posterior cerebral and superior cerebellar arteries and then through the cisterna interpeduncularis. After traversing the small triangular space between the free and attached borders of the tentorium cerebelli, it pierces the dura mater lateral to the posterior clinoid process. Thereafter it runs along the lateral wall of the cavernous sinus; here it lies above the trochlear nerve and receives communicating twigs from the cavernous plexus of the sympathetic and from the ophthalmic division of the trigeminal. It then passes to the orbit through the superior orbital fissure where it breaks up into a superior and an inferior division. The two divisions enter the orbit between the two heads of the rectus lateralis; here it lies below the trochlear, frontal and lacrimal nerves while the nasociliary nerve lies between the two divisions. The *superior division* passes above the optic nerve and supplies the levator palpebræ superioris and superior rectus muscles. The *inferior division* breaks up into three branches for the supply of the rectus medialis, the rectus inferior and the obliquus inferior. The nerve to the last named muscle is long and gives off the short or parasympathetic root to the ciliary ganglion; it passes forwards between the rectus inferior and the rectus lateralis to enter the posterior border of the inferior oblique muscle.

## The Trochlear Nerve

The **trochlear nerve** (Fig. 27 ) is the smallest of the cerebral nerves and is motor only to the obliquus superior oculi. The fibres of this nerve arise from a nucleus which is situated in the grey substance of the floor of the cerebral aqueduct on a level with the inferior colliculus. From this origin the fibres of the nerve pass to the tegmentum and then into the upper part of the anterior medullary velum. Here the nerve crosses to the opposite side, decussating with its fellow; thereafter it emerges from the upper end of the velum by the side of the frenulum veli where it makes its superficial appearance. It next turns lateralwards over the brachium conjunctivum cerebelli and then winds round the cerebral peduncle and continues its course forwards. It next pierces the free border of the tentorium cerebelli posterolateral to the posterior clinoid process and proceeds to the lateral wall of the cavernous sinus; it lies in the lateral wall of the sinus between the oculomotor nerve and the ophthalmic division of the trigeminal nerve and receives communicating twigs from the latter nerve and the cavernous plexus of the sympathetic. It crosses the oculomotor nerve and passes through the superior orbital fissure to enter the orbit; here it lies medial to the frontal nerve and passes above the origin of the levator palpebræ superioris to end in the back part of the orbital surface of the superior oblique muscle.

## The Trigeminal Nerve

The **trigeminal nerve** (Fig. 275) is the largest of the cerebral nerves and is the nerve of common sensation of the face and greater part of the scalp, and is motor to the muscles of mastication. It resembles a spinal nerve in having two roots, sensory and motor, of which the former is large and has a ganglion called called the **semilunar ganglion** (Gasserian ganglion). The fibres of the *sensory root* arise from the cells of the semilunar ganglion. This ganglion is a semilunar mass and lies in a cavity (Meckel's cave) in the dura mater above the trigeminal impression on the apex of the petrous portion of the temporal bone; the medial end of the ganglion is in relation with the cavernous sinus and the internal carotid artery, and the lateral end lies to the medial side of the foramen ovale; its upper surface is in relation with the temporal lobe of the brain from which it is separated by dura mater; its lower surface with the motor root of the nerve. From the convexity of the ganglion three large nerves arise—the ophthalmic or first division, the maxillary or second division, and the mandibular or third division. The motor root of the nerve passes beneath the ganglion and is blended wholly with the mandibular division. The fibres of the sensory root, after their origin from the cells of the semilunar ganglion, leave the concave margin of the ganglion, and run backwards over the upper border of the petrous portion of the temporal bone into the posterior cranial fossa. In the posterior fossa the fibres run backwards and downwards and enter the pons. In the tegmentum of the pons the fibres divide into ascending and descending branches, as in the case of the fibres of the posterior roots of the spinal nerves. The terminal nuclei of these ascending and descending fibres are two; an upper and a lower. The ascending branches are short and almost immediately terminate in the *upper sensory nucleus* which is placed in the lateral part of the tegmentum of the pons. The *lower sensory nucleus* continues the line of the upper sensory nucleus and is in reality the enlarged upper end of that column of grey substance which is known as the substantia gelatinosa of Rolando. When the descending branches are traced they are found to pass downwards and form what is called the *spinal tract of the trigeminal nerve.* The tract descends through the pons and medulla oblongata on the lateral side of the substantia gelatinosa and disappears in the upper part of the medulla spinalis, about the level of the first or second spinal nerve. The fibres of the small *motor root* are derived from two nuclei, pontine and mesencephalic. The *pontine* or *chief motor nucleus* is situated in the lateral part of the tegmentum of the pons, close to the medial side of the upper sensory nucleus. The *mesencephalic* or *accessory nucleus* is situated in the lateral part of the grey substance surrounding the cerebral aqueduct. The fibres which arise from this nucleus enter the pons and join the more numerous fibres from the pontine nucleus and form the motor root. The motor root makes its superficial appearance at the upper border of the ventral surface of the pons; the sensory root makes its superficial appearance also at that site—the former lies in front of and medial to the latter. Some hold the view that the mesencephalic root is sensory and not motor.

## The Ophthalmic Nerve

The **ophthalmic nerve** (Fig. 275) is the smallest of the three divisions of the trigeminal nerve and is entirely sensory in function. It passes forwards in the lateral wall of the cavernous sinus; here it lies below the trochlear nerve and lateral to the abducent nerve and internal carotid artery; it gives off a recurrent branch, *n. tentorii*, to the dura mater, and communicating twigs to the cavernous plexus of the sympathetic, to the oculomotor, trochlear and abducent nerves. It then reaches the orbit by passing through the superior orbital fissure where it divides into three branches, the frontal, lacrimal, and nasociliary.

The **frontal nerve** is the largest of the three branches of the ophthalmic nerve. Entering the orbit through the superior orbital fissure, it runs forwards between the levator palpebræ superioris and the periosteum and terminates about the middle of the orbit by dividing into two branches, the supratrochlear and the supraorbital.

The *supratrochlear nerve* is the medial terminal branch of the frontal nerve. It passes forwards and medialwards above the pulley of the superior oblique muscle and piercing the orbital septum emerges from the orbit at its upper and medial angle. It then ascends beneath the corrugator and frontalis muscles, pierces the frontalis muscle and supplies the skin of the forehead near the middle line. The *supraorbital nerve* is the lateral terminal branch of the frontal nerve. It emerges from the orbit through the supraorbital notch or foramen and ascends beneath the orbicularis oculi and frontalis muscles. It then divides into two branches, a medial and a lateral. The medial branch pierces the frontalis muscle; the lateral branch pierces the galea aponeurotica; both branches supply the forehead and scalp reaching as far back as the vertex.

The **lacrimal nerve** is the smallest of the three branches of the ophthalmic nerve. Entering the orbit through the superior orbital fissure, it runs along the upper margin of the lateral rectus muscle in company with the lacrimal artery. It is then continued forwards beneath the lacrimal gland to which it supplies filaments; it pierces the orbital septum and terminates in the skin of the upper eyelid. Near the lacrimal gland it gives a twig which passes downwards to communicate with the zygomatic branch of the maxillary nerve.

The **nasociliary nerve** (nasal nerve) enters the orbit between the two heads of the rectus lateralis and between the two divisions of the oculomotor nerve. Crossing the optic nerve it passes medialwards between the rectus medialis and superior oblique muscles and enters the anterior ethmoidal foramen under the name of the anterior ethmoidal nerve.

The *anterior ethmoidal nerve* passes through the anterior ethmoidal foramen and enters the cranial cavity and passes forwards along the lateral edge of the lamina cribrosa of the ethmoidal bone under cover of the dura mater. It then enters the nasal cavity through a slit by the side of the crista galli and runs downwards along the inner surface of the nasal bone. Here it gives off *internal nasal branches* to the mucous membrane of the nose. Finally it leaves the nasal cavity and appears on the face as the *external nasal nerve* between the lower border of the nasal bone and the lateral cartilage of the nose and supplies the skin of the ala and tip of the nose.

The **branches** of the nasociliary nerve are ; (1) The *long root of the ciliary ganglion* arises as the nerve proceeds between the two heads of the rectus lateralis ; it then passes along the lateral side of the optic nerve to join the posterosuperior angle of the ciliary ganglion. Sometimes the sympathetic root of the ciliary ganglion which is derived from the cavernous plexus joins the long root. (2) The *long ciliary nerves,* two or three in number, arise from the nasociliary as it crosses the optic nerve and proceed forwards to the eyeball where they pierce the back part of the sclera to supply the ciliary body, iris and cornea. (3) The *posterior ethmodial nerve* passes through the posterior ethmodial foramen to supply the ethmodial cells and the sphenoidal sinus. (4) The *infratrochlear nerve* arises from the nasociliary just before it enters the anterior ethmoidal foramen and passes beneath the pulley of the superior oblique muscle. It then leaves the orbit and appears on the face and supplies the skin of the eyelids and root of the nose. Near the pulley it is joined by a filament from the supratrochlear nerve.

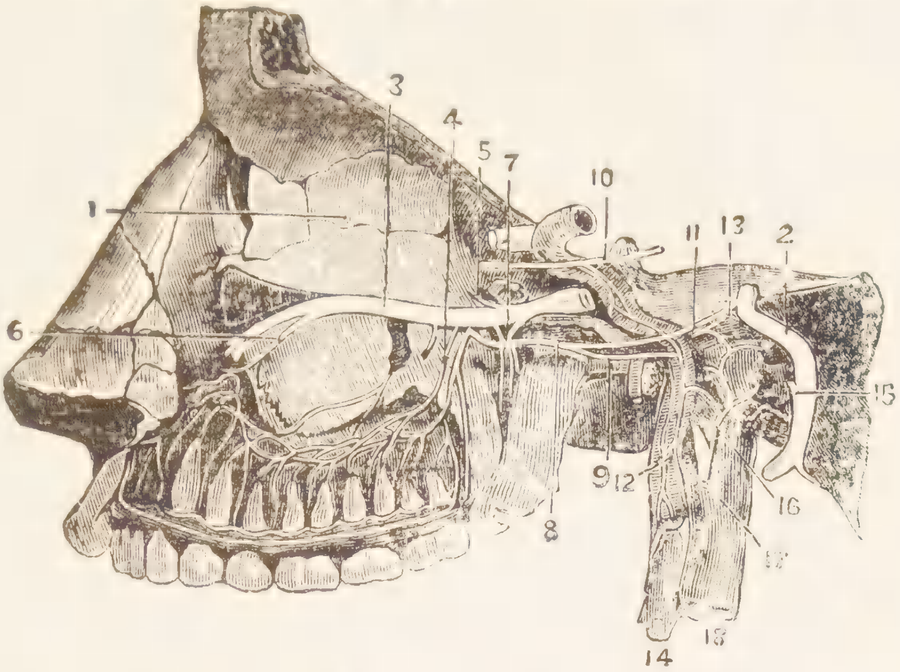
### The Maxillary Nerve

The **maxillary nerve** (Fig. 276) is intermediate in size between the ophthalmic and mandibular nerves and is entirely sensory in function. It springs from the middle of the semilunar ganglion and runs forwards in the lower part of the lateral wall of the cavernous sinus. It leaves the cranial cavity through the foramen rotundum and, crossing the upper part of the pterygopalatine fossa, inclines lateralwards and enters the orbit through the inferior orbital fissure. It then traverses the infraorbital canal in the floor of the orbit assuming the name of the *infraorbital nerve* which is thus the terminal part of the maxillary nerve ; it is accompanied by the infraorbital vessels in the canal. It issues out of the infraorbital foramen and appears on the face under cover of the quadratus labii superioris and immediately divides into inferior palpebral, external nasal, and superior labial branches.

The **branches** of the maxillary nerve are :—(*a*) *In the cavity of the cranium*—(1) middle meningeal ; (*b*) *in the pterygopalatine fossa*—(2) zygomatic, (3) sphenopalatine, (4) posterior superior alveolar ; (*c*) *in the infraorbital canal*—(5) middle superior alveolar, (6) anterior superior alveolar ; (*d*) *after emerging on the face*—(7) inferior palpebral, (8) external nasal, (9) superior labial.

(1) The **middle meningeal nerve** accompanies the middle meningeal artery and supplies the dura mater of the middle fossa of the skull.

(2) The **zygomatic nerve** (temporomalar nerve) arises from the maxillary nerve in the pterygopalatine fossa and, entering the orbit through the inferior orbital fissure, divides into two branches, the zygomaticotemporal and the zygomaticofacial. The *zygomaticotemporal branch* passes along the lateral wall of the orbit and receives a communicating filament from the lacrimal nerve. It issues out of the orbit through a foramen in the zygomatic bone and appears in the temporal fossa. It then ascends in this fossa, pierces the temporal fascia about an inch above the front part of the zygomatic arch and supplies the skin of the temporal region. The *zygomaticofacial branch* also issues out of the orbit through a foramen in the zygomatic bone and appears on the face. It pierces the orbicularis oculi and supplies the skin over the zygomatic bone; it communicates with the zygomatic branches of the facial nerve.



Fig, 276.—The maxillary nerve and sphenopalatine ganglion.

1. Medial wall of orbit.
2. Facial nerve.
3. Maxillary nerve.
4. Posterior superior alveolar nerve.
5. Zygomatic branch (cut).
6. Anterior superior alveolar nerve.
7. Sphenopalatine ganglion.
8. Nerve of pterygoid canal.
9. Deep petrosal nerve.
10. Abducent nerve.
11. Greater superficial petrosal nerve.
12. Internal carotid plexus of sympathetic.
13. Lesser superficial petrosal nerve.
14. Superior cervical ganglion.
15. Chorda tympani nerve.
16. Tympanic branch of glossopharyngeal nerve.
17. Glossopharyngeal nerve.
18. Internal jugular vein.

(3) The **sphenopalatine branches**, two in number, descend to join the sphenopalatine ganglion and constitute its sensory roots.

(4) The **posterior superior alveolar nerve** (posterior superior dental nerve) arises before the maxillary nerve enters the orbit. It divides into two branches which descend along the infratemporal surface of the maxilla and supply filaments to the gum and the mucous membrane of the cheek. They then enter the posterior alveolar canals and supply the lining membrane of the

maxillary air sinus and the three molar teeth. The posterior superior alveolar nerve communicates with the anterior and middle superior alveolar nerves to form the *superior dental plexus*.

(5) The **middle superior alveolar nerve** arises from the infraorbital nerve at the back part of infraorbital canal and descends through a minute canal in the lateral wall of the maxillary sinus to supply the two premolar teeth.

(6) The **anterior superior alveolar nerve** arises from the infraorbital nerve at the front part of the infraorbital canal. It descends through a minute canal in the anterior wall of the maxillary sinus and, after giving off a branch to the mucous membrane of the anterior part of the inferior meatus, supplies filaments to the incisor and canine teeth.

(7) The **inferior palpebral branches**, usually two, pass upwards and supply the skin and conjunctiva of the lower eyelid.

(8) The **external nasal branches** supply the skin of the side of the nose.

(9) The **superior labial branches** supply the skin and mucous membrane of the upper lip ; they communicate with the zygomatic and buccal branches of the facial nerve and form the *infraorbital plexus*.

### The Mandibular Nerve

The **mandibular nerve** (inferior maxillary nerve) (Figs. 215, 275) is the largest of the three divisions of the trigeminal nerve. It is a mixed nerve, consisting of two roots, motor and sensory. The sensory root is large and arises from the semilunar ganglion ; the motor root is small and constitutes the entire motor root of the trigeminal nerve. The two roots pass together in the duramater of the middle cranial fossa to the foramen ovale and unite with each other either inside the foramen or just after their exit from it to form the mandibular nerve. The mixed nerve trunk lies under cover of the pterygoideus externus and immediately divides into an anterior and a posterior division. Before division, two branches, viz., the nervus spinosus and the nerve to the pterygoideus internus are given off from the main trunk.

The **nervus spinosus** (recurrent branch) enters the cranial cavity through the foramen spinosum with the middle meningeal artery and supplies the dura mater.

The **nerve to the pterygoideus internus** is a slender branch which passes forwards to enter the deep surface of the internal pterygoid muscle. It gives off one or two filaments which constitutes the motor root of the otic ganglion.

The anterior division (**nervus masticatorius**) of the mandibular nerve is the smaller of the two divisions. It contains motor and sensory fibres and divides into branches which supply the muscles of mastication and the skin and mucous membrane of the cheek. It gives off the following branches :—(1) masseteric, (2) deep temporal, (3) external pterygoid, and (4) buccinator.

The **masseteric nerve** passes above the pterygoideus externus and crosses the mandibular notch with the artery of the same name to enter the deep surface of the masseter. It gives a filament to the temporomandibular joint.

The **deep temporal nerves** are two in number, an anterior and a posterior. They run upwards above the pterygoideus externus and enter the deep surface of the temporalis muscle.

The **nerve to the pterygoideus externus** enters the deep surface of the muscle ; it generally arises in common with the buccinator nerve.

The **buccinator nerve** (long buccal nerve) runs forwards between the two heads of the external pterygoid muscle and then downwards under cover of the temporalis. Emerging from beneath the anterior border of the masseter it lies on the superficial surface of the buccinator and communicates with the buccal branches of the facial nerve forming the *buccal plexus.* Filaments from the plexus supply the skin and the mucous membrane of the cheek. A *temporal branch* is given off from this nerve after its passage through the external pterygoid muscle and enters the deep surface of the temporalis.

The posterior division of the mandibular nerve contains mainly sensory fibres but receives some fibres from the motor root also. It divides into three branches (1) auriculotemporal, (2) lingual, and (3) inferior alveolar.

The **auriculotemporal nerve** arises by two roots between which the middle meningeal artery passes. It runs backwards under cover of the pterygoideus externus to the neck of the mandible. It then proceeds upwards in company with the superficial temporal artery between the auricula and the condyle of the mandible under cover of the parotid gland. It crosses the zygomatic arch in front of the ear acompanied by the superficial temporal artery and reaches the temporal region where it is distributed as a cutaneous nerve of the temple and scalp. Its branches are :—(1) *Communicating branches* to the otic ganglion and facial nerve. Two twigs from the otic ganglion join the two roots of the nerve ; the two filaments to the facial nerve pass forwards to join that nerve at the posterior border of the masseter muscle. (2) The *articular branches* are one or two twigs which enter the mandibular joint. (3) The *parotid branches* supply the parotid gland. (4) The *auricular branches* are usually four in number : two of them supply the skin of the external acoustic meatus by passing through the bony and cartilaginous portions of the canal ; the other two filaments supply the skin of the upper and front part of the auricula. (5) The *temporal branches* accompany the superficial temporal artery and supply this skin of the temporal region.

The **lingual nerve** is purely sensory. It lies at first under cover of the external pterygoid muscle and is joined in this situation at an acute angle by the chorda tympani nerve. Emerging from the lower border of the muscle it lies in front of and medial to the inferior alveolar nerve, runs downwards and forwards between the ramus of the mandible and the internal pterygoid muscle and reaches the submaxillary region. It then proceeds forwards over the constrictor pharyngis superior and reaches a point below the last molar tooth. It continues its forward course along the side of the tongue and crosses the styloglossus, the hyoglossus, and the submaxillary duct and reaches the tip of the tongue being covered only by the mucous membrane. It gives off *communicating branches* to the submaxillary ganglion and to the hypoglossal nerve. The latter form one or two loops near the anterior border of the hyoglossus. The *branches of distribution* supply the mucous membrane of the mouth, the gums and the sublingual gland ; some branches go to supply the mucous membrane and papillæ over the anterior two-thirds of the tongue by piercing the substance of the organ.

The **inferior alveolar nerve** (inferior dental nerve) is the largest branch of the mandibular nerve. It is chiefly sensory but also contains some motor fibres. It emerges from the lower border of the external pterygoid muscle behind the lingual nerve and reaches the interval between the ramus of the mandible and sphenomandibular ligament. It then enters the mandibular foramen and traverses the mandibular canal in company with the inferior alveolar artery distributing branches to the teeth in its course and terminates opposite the mental foramen by dividing into an incisive and a mental branch. The *branches* of the inferior alveolar nerve are (1) the mylohyoid, (2) the dental, (3) the incisive, and (4) the mental. The *mylohyoid nerve* constitutes the motor fibres contained in the inferior alveolar nerve —these motor fibres quit the inferior alveolar nerve just before its entrance into the mandibular foramen and constitute the mylohoid nerve. It runs along the mylohoid groove of the mandible in the submaxillary triangle where it supplies the mylohyoid muscle and the anterior belly of the digastricus. The *dental branches* arise within the mandibular canal and communicate with one another forming the *inferior dental plexus* from which filaments supply the molar and premolar teeth. The *incisive branch* courses forwards within the canal and supplies the canine and incisor teeth. The *mental branch* emerges through the mental foramen and communicates with the mandibular branch of the facial nerve ; it breaks up into branches which supply the chin and lower lip.

## Ganglia associated with Cerebral Nerves

Four small ganglia associated with the cerebral nerves or rather with the trigeminal nerve may be conveniently described now. Properly speaking these ganglia belong to the sympathetic system in as much as although the branches of the trigeminal nerve go to form their roots, functionally the trigeminal nerve has little to do with these ganglia. In fact these ganglia are regarded by some anatomists as representing the upward extension of the ganglia of the sympathetic trunks and are designated as the *cephalic sympathetic ganglia*. These ganglia are four in number viz., the ciliary, the sphenopalatine, the otic, and the submaxillary.

The **ciliary ganglion** (lenticular ganglion) (Fig. 274) is a minute reddish body of the size of a pin's head, quadrangular in shape, and situated at the back part of the orbit between the rectus lateralis and the optic nerve. Like all cerebral ganglia it has three roots which enter its posterior border. The short or *parasympathetic root* is thick and is derived from the branch of the inferior division of the oculomotor nerve which goes to supply the inferior oblique muscle ; it joins the postero-inferior angle of the ganglion. The long or *sensory root* is slender and joins the postero-superior angle of the ganglion ; it is derived from the nasociliary nerve. The *sympathetic root* is derived from the cavernous plexus of the sympathetic and joins the ganglion below the sensory root ; sometimes it joins the sensory root itself. The *branches* of the ciliary ganglion are the *short ciliary nerves* which arise from the anterior border of the ganglion. They are six to ten in number and are arranged in two groups ; an upper group, running above the optic nerve and a lower group, below that nerve. They proceed forwards accompanied by the ciliary arteries and long ciliary nerves and pierce the sclera around the optic nerve to supply the iris, cornea and the ciliary muscle.

The **sphenopalatine ganglion** (Meckel's ganglion) (Figs. 275, 276) is triangular in shape and placed in the pterygopalatine fossa just lateral to the sphenopalatine foramen. It is surrounded by the terminal branches of the internal maxillary artery. Its *sensory roots* are derived from the two sphenopalatine branches of the maxillary nerve, which join it from above. Its *parasympathetic* and *sympathetic roots* are derived through the nerve of the pterygoid canal which join the ganglion posteriorly. The nerve of the pterygoid canal is formed by the union of the greater superficial petrosal and deep petrosal nerves ; of these the former contains parasympathetic fibres from the facial nerve and the latter contains sympathetic fibres from the internal carotid plexus.

The **branches** of the sphenopalatine ganglion are :—(1) The *posterior superior nasal branches* arise from the medial aspect of the ganglion and enter the nasal cavity through the sphenopalatine foramen. The largest of these branches is called the *nasopalatine nerve.* It crosses the roof of the nasal cavity medialwards and runs downwards and forwards along the nasal septum where it lies in the groove on the lateral surface of the vomer between the mucous membrane and the periosteum. It then passes through the incisive canal and ends in the mucous membrane of the front of the hard palate, communicating with the nerve of the opposite side and anterior palatine nerve. The smaller posterior superior nasal branches supply the back part of the septum and the lateral wall of the nasal cavity. (2) The *pharyngeal nerve* arises from the posterior part of the ganglion and passes through the pharyngeal canal accompanied by the pharyngeal branch of the internal maxillary artery and supplies the mucous membrane of the nasal part of the pharynx. (3) The *orbital branches* are two or three filaments which enter the orbit through the inferior orbital fissure to supply the periosteum of the orbit, the lacrimal gland and orbitalis muscle. (4) The *palatine nerves* are three in number : anterior, middle and posterior. They arise from the lower part of the ganglion. The *anterior palatine nerve* descends through the pterygopalatine canal with the descending palatine vessels and, entering the hard palate through the greater palatine foramen, passes forwards and supplies the mucous membrane of the hard palate and the gums. It communicates near the incisive foramen with the terminal filaments of the nasopalatine nerve. It gives off *posterior inferior nasal branches* which enter the lateral wall of the nasal cavity through apertures in the vertical plate of the palatine bone. The *middle palatine nerve* issues out of one of the lesser palatine foramina in the pyramidal process of the palatine bone and supplies the soft palate and the tonsil. The *posterior palatine nerve* emerges through a separate lesser palatine foramen behind and lateral to the preceding and supplies the soft palate and tonsil.

The **otic ganglion** is a small oval ganglion placed immediately below the foramen ovale, on the medial side of the mandibular nerve, and in front of the middle meningeal artery. Its *motor root* is formed by two or three filaments derived from the nerve to the pterygoideus internus ; the *sensory root* is derived from the lesser superficial petrosal nerve which joins the ganglion at its posterior border ; the *parasympathetic root* is supplied by the lesser superficial petrosal nerve. The *sympathetic root* comes from the plexus around the middle meningeal artery. The *branches* of the otic ganglion are :—(1) branch to the tensor veli palatini which passes forwards and enters the muscle, (2) a twig which passes backwards and supplies the tensor tympani, and (3) communicating filaments to the chorda tympani nerve and filaments to one or both roots of the auriculotemporal nerve which carry secretory (parasympathetic) fibres to the parotid galnd.

The **submaxillary ganglion** (Fig. 277) is a very small ganglion placed upon the hyoglossus muscle between the lingual nerve and the deep portion of the submaxillary gland. It appears to be suspended from the lingual nerve by two filaments, an anterior and a posterior. The posterior filament carries to the ganglion parasympathetic fibres from the chorda tympani branch of the facial nerve and also sensory fibres from the lingual proper. The anterior filament is regarded as a branch given off from the ganglion to the lingual nerve for distribution to the sublingual gland. Thus the *parasympathetic root* of the ganglion is derived from the chorda tympani and the *sensory root* from the lingual. The *sympathetic root* of the ganglion is derived from the plexus around the external maxillary artery. From the ganglion branches are supplied to the submaxillary gland and its duct, to the sublingual gland, and to the mucous membrane of the mouth.

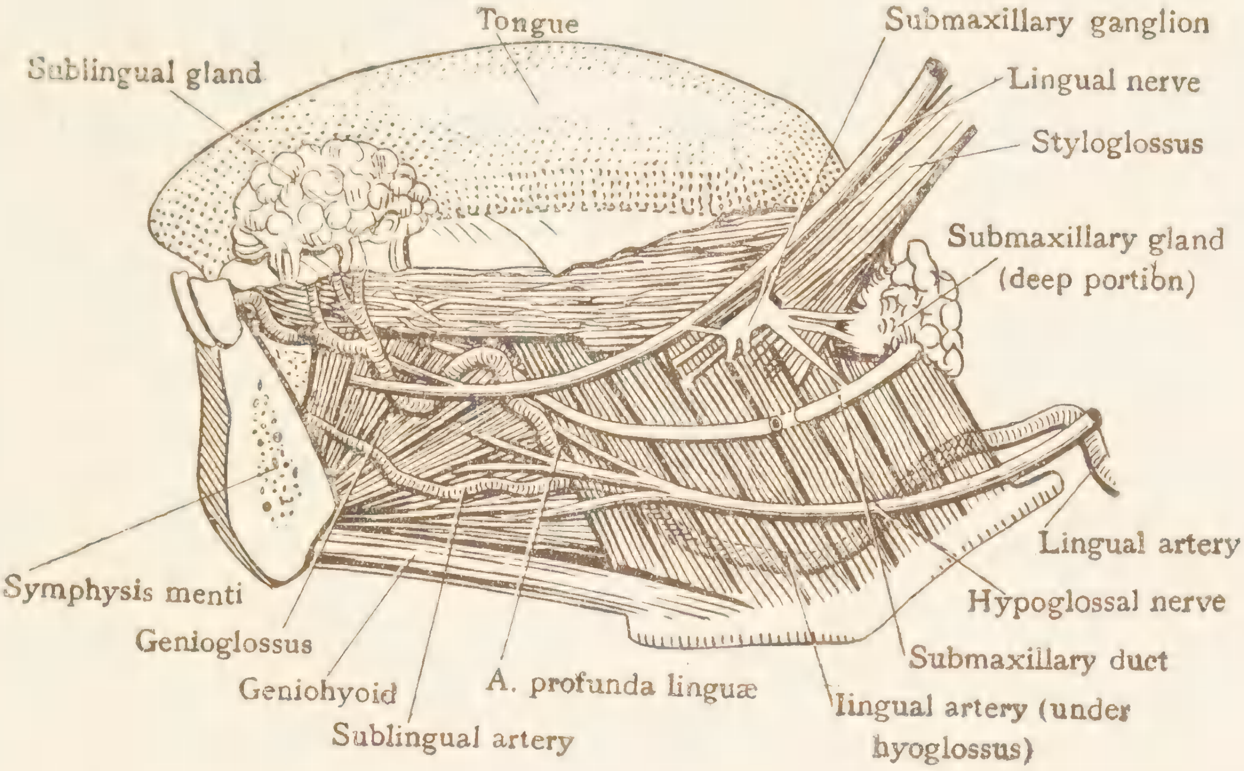


Fig. 277.—Dissection of the submaxillary region showing the submaxillary ganglion.

## The Abducent Nerve

The **abducent nerve** (Fig. 274) supplies only the rectus lateralis oculi. Its fibres arise from the cells of a small spherical nucleus which is situated in the dorsal part of the tegmental portion of the pons. The nucleus occupies a position above the level of the striæ medullares on the floor of the fourth ventricle subjacent to the colliculus facialis. The fibres pass forwards and downwards through the pons medial to the superior olivary nucleus, and the nerve makes its superficial appearance at the lower border of the pons just above the pyramid of the medulla oblongata. The nerve passes forwards, pierces the dura mater at the lower border of the dorsum sellae where a notch exists for it on either side. It then passes along the medial wall of the cavernous sinus lateral to the internal carotid artery covered by the lining membrane of the sinus ; here it receives communicating filaments from the carotid plexus of the sympathetic and from the ophthalmic nerve. Thereafter it enters the orbit through the superior orbital fissure. Finally it passes between the two heads of the rectus lateralis and enters the deep or ocular surface of the muscle to supply it.

**Cerebral nerves in the cavernous sinus.**—The lateral wall of the cavernous sinus contains the following cerebral nerves in this order from above downwards : the oculomotor, the trochlear, the ophthalmic ; the cavity of the sinus is traversed by the abducent nerve which lies to the lateral side of the cavernous portion of the internal carotid artery. The nerves are separated from the blood flowing in the sinus by a thin lining membrane of the sinus.

**Cerebral nerves in the superior orbital fissures.**—In this fissure and upon the same plane are placed the frontal nerve in the middle the lacrimal nerve on the lateral side, and the trochlear nerve on the medial side. The remaining nerves which enter into the orbit pass between the two heads of the rectus lateralis and lie in the following order from above downwards : the superior division of the oculomotor, the nasociliary, the inferior division of the oculomotor, and the abducent.

**Cerebral nerves in the orbit.**—Beneath the periosteum are the frontal nerve in the middle, the lacrimal nerve on the lateral side, and the trochlear nerve on the medial side ; the frontal lies on the levator palpebræ superioris, the lacrimal on the rectus lateralis, and the trochlear on the obliquus superior. The nasociliary nerve crosses the optic nerve and passes medialwards. The superior division of the oculomotor passes above the optic nerve while the inferior division, below that nerve. The abducent nerve lies below the optic nerve and enters the ocular surface of the rectus lateralis.

## The Facial Nerve

The **facial nerve** (Fig. 214) is a mixed nerve composed of two parts : a large motor part, called the *facial nerve proper*, which supplies the superficial muscles of the neck, face, and scalp and also some deep muscles ; and a small sensory part, called the *nervus intermedius* of Wrisberg, which contains the fibres of taste for the anterior two-thirds of the tongue. The *motor part* arises from a nucleus which is situated deeply in the dorsal part of the lower portion of the pons. From this nucleus the fibres of the nerve pursue a long, intricate course within the pons before making a superficial appearance at the lower border of the pons in the interval between the olive and the restiform body of the medulla oblongata. From the point of origin to the point of emergence the fibres run at first backwards and medialwards to the floor of the fourth ventricle and reach the posterior end of the nucleus of the abducent nerve constituting what is known as the *radicular portion.* Next they turn upwards along the medial side of the abducent nucleus and are collected in the form of a single compact bundle in this ascending course constituting what is known as the *ascending portion.* At the anterior end of the abducent nucleus the nerve makes a sharp bend laterally and passes forwards through the pons to its place of emergence constituting what is known as the *emergent portion ;* this bend causes the projection in the floor of the fourth ventricle known as colliculus facialis. The *sensory part* arises from the cells of the genicular ganglion which is embedded on the *geniculum* (great bend) of the facial nerve in the facial canal of the temporal bone. This ganglion is similar to the semilunar ganglion of the trigeminal and the ganglion of the posterior root of spinal nerve and consists of unipolar cells—the single process of each cell divides into a peripheral and a central branch. The peripheral branches go to form portions of the greater superficial petrosal and chorda tympani nerves. The central branches penetrate the brain and pass alongside the spinal tract of the trigeminal nerve and terminate in the nucleus fasciculus solitarii. From the facial canal the sensory part passes into the internal acoustic meatus; emerging from the meatus it passes to the lower border of the pons where it lies between the motor portion and the acoustic nerve. The motor portion makes its superficial appearance at the lower border of the pons in front of and medial to the acoustic nerve.

The facial nerve consists of the following parts: (1) the first or intrapontine part; (2) the second or petrous part; (3) the third or terminal part.

The **first** or **intrapontine part** extends from the nucleus of origin of the nerve to its superficial appearance. This part has been described.

The **second** or **petrous part** of the nerve lies in the petrous portion of the temporal bone and presents four stages. The *first stage* is in the internal acoustic meatus where the facial nerve consisting of its motor and sensory roots passes above and anterior to the acoustic nerve; the sensory root lying between the motor root and the acoustic nerve; the two roots join within the meatus. In the *second stage* the facial nerve trunk enters the facial canal at the bottom of the meatus; in the facial canal the nerve at first runs lateralwards over the vestibule between the cochlea in front and the semicircular canals behind and presents a swelling called the *genicular ganglion* or the nucleus of the sensory root of the nerve. In the *third stage*, the nerve bends backwards abruptly at the ganglion, passes along the upper part of the medial wall of the tympanic cavity and reaches the posterior wall of the cavity. In the *fourth stage*, the nerve descends almost vertically to its point of exit from the stylomastoid foramen.

The **third** or **terminal part** begins from its emergence through the stylomastoid foramen. It then runs downwards and forwards in the substance of the parotid gland, and, near the posterior border of the ramus of the mandible, breaks up into two divisions, called the temporofacial and cervicofacial.

**Branches** and **communications.**—The *petrous part* of the nerve gives off: (1) a communicating branch to the acoustic nerve in the internal acoustic meatus; (2) three branches arise from the genicular ganglion viz., the greater superficial petrosal, a minute branch which joins the tympanic branch of the glossopharyngeal in the substance of the petrous bone, and the external superficial petrosal nerve; (3) in the lower part of the facial canal three branches arise viz., the nerve to the stapedius, chorda tympani, and a communicating filament to the auricular branch of the vagus. The *terminal part* of the nerve gives off: at its emergence through the stylomastoid foramen three branches viz., the posterior auricular, digastric branch, and stylohyoid branch; in the parotid gland, the temporofacial and cervicofacial divisions.

The **greater superficial petrosal nerve** arises from the genicular ganglion and contains chiefly sensory fibres. It receives a twig from the tympanic plexus and probably also contains a few fibres which form the parasympathetic root of the sphenopalatine ganglion. It passes forwards through the hiatus of the facial canal with the petrosal branch of the middle meningeal artery. It then runs in a groove on the anterior surface of the petrous bone beneath the semilunar ganglion to the foramen lacerum; in the upper part of this foramen it joins the deep petrosal nerve from the sympathetic plexus on the internal carotid artery to form the *nerve of the pterygoid canal* which traverses the pterygoid canal and ends in the sphenopalatine ganglion.

The **external superficial petrosal nerve** is a minute inconstant branch which arises from the genicular ganglion and joins the sympathetic plexus around the middle meningeal artery.

The **nerve to the stapedius** arises from the facial nerve in the facial canal opposite the pyramid of the tympanum. It enters a small canal in that eminence and thus reaches the stapedius which lies within the canal.

The **chorda tympani nerve** is at first associated with the nervous intermedius. It leaves the trunk of the facial nerve a short distance above the stylomastoid foramen and pursues a recurrent course upwards and forwards through a minute canal called the iter chordæ posterius by which it enters the tympanum. It traverses the tympanic cavity, appearing first on its posterior wall close to the posterior border of the tympanic membrane and then passing to the medial side of the manubrium of the malleus, lying between the fibrous and mucous layers of the tympanic membrane. It leaves the tympanic cavity through the iter chordæ anterius. It then grooves the spina angularis of the sphenoid and reaches the medial surface of the pterygoideus externus; after receiving a fine twig from the otic ganglion and on that muscle it joins the lingual nerve at an acute angle and becomes incorporated with and inseparable from that nerve in its further course. It contains a few efferent parasympathetic fibres—these form a root of the submaxillary ganglion through which the submaxillary and sublingual glands are supplied. It chiefly contains afferent fibres which continue their forward course through the muscular substance of the tongue and are finally distributed to the anterior two thirds of the tongue and constitute the nerve of taste for this portion of the organ.

The **posterior auricular nerve** arises close to the stylomastoid foramen and runs upwards with the posterior auricular artery in the interval between the mastoid process and the auricula and divides into an anterior or auricular branch and a posterior or occipital branch. The auricular branch supplies the auricularis posterior and the intrinsic muscles of the auricula. The occipital branch passes backwards and supplies the occipitalis.

The **digastric branch** and the **stylohyoid branch** arise close to the stylomastoid foramen ; the former supplies the posterior belly of the digastricus by several filaments, one of the filaments joining the glossopharyngeal ; the latter supplies the stylohyoideus.

The *terminal divisions*, called *temporofacial* and *cervicofacial*, run in the substance of the parotid gland and lie superficial to the external carotid artery and to the posterior facial vein. Each division breaks up within the gland into two or three branches which ramify in the gland, on the face and upper part of the neck and communicate freely like a plexus which is known as the *plexus parotideus* or *pes anserinus*. The temporofacial division divides into temporal and zygomatic branches. The cervicofacial division divides into buccal, mandibular, and cervical branches.

The **temporal branches** emerge from the upper border of the parotid gland and cross the zygomatic arch to gain the temporal region of the scalp. They supply the corrugator, orbicularis oculi, frontalis, and auriculares anterior and superior muscles. The **zygomatic branches** emerge from the anterior border of the parotid gland and pass forwards above the parotid duct and across the zygomatic bone to the lateral angle of the orbit. They supply the orbicularis oculi and communicate with the lacrimal nerve and the zygomaticofacial branch of the maxillary nerve. The lowest branch unites with filaments from the buccal branches and the infraorbital nerve to form the *infraorbital plexus*. The **buccal branches** emerge from the anterior border of the parotid gland and pass forwards below the parotid duct towards the angle of the mouth. The upper branches ascend beneath the zygomaticus and the quadratus labii superioris and form the infraorbital plexus beneath the latter muscle. These branches and filaments from the plexus supply the muscles of the nose and the muscles of the upper lip. The lower branches supply the buccinator and the orbicularis oris and communicate with the buccinator branch of the mandibular nerve on the buccinator muscle. The **mandibular branch** (inframaxillary branch) emerges from the anterior border of the parotid gland, passes forwards and downwards beneath the triangularis and supplies the muscles of the lower lip and chin. Beneath the triangularis it communicates with the mental branch of the inferior alveolar nerve. The **cervical branch** emerges from the lower border of the parotid gland, runs down the side of the neck in the anterior triangle and supplies the platysma.

## The Acoustic Nerve

The **acoustic nerve** is the nerve of hearing and of equilibrium and consists of two entirely separate portions, the cochlear nerve or the nerve of hearing and the vestibular nerve or the nerve concerned with the maintenance of equilibrium. The fibres of the cochlear nerve arise from the cells of the spiral ganglion of the cochlea situated in the spiral canal of the modiolus while the fibres of the vestibular nerve arise from the cells of the vestibular ganglion situated at the deep end of the internal acoustic meatus. The two nerves make their superficial appearance at the lower border of the pons lateral to the facial nerve and ventral to the restiform body. Thereafter the two nerves pursue different courses; the cochlear passes round the lateral side of the restifirm body and the vestibular round its medial side. When the whole course of the acoustic nerve is considered it will be evident that the cochlear and vestibular nerves have entirely separate deep connexions in the brain, that their peripheral distribution are also separate, and that they remain distinct throughout—it is only the combined trunk of the two nerves that is designated as the acoustic nerve.

The **cochlear nerve** possesses two terminal nuclei, ventral and dorsal. The *ventral* or *accessory nucleus* lies on the ventral surface of the restiform body in the interval between the cochlear and vestibular nerves. The *dorsal nucleus* is situated on the dorsal surface of the restiform body in the interval between the flocculus and restiform body. The fibres of the cochlear nerve enter these two nuclei and end around their cells in arborizations. The fibres issuing from the dorsal cochlear nucleus pass over the restiform body as the striæ medullares across the floor of the fourth ventricle to the median sulcus where they dip—some cross to end in the opposite superior olivary nucleus; others pass to the superior olivary nucleus of the same side. Some fibres from the dorsal nucleus do not end in the superior olivary nuclei of the same or opposite side but ascend uninterruptedly along the lateral lemniscus of the same or opposite side. The fibres issuing from the ventral cochlear nucleus pass transversely into the pons forming the trapezoid body of the pons and end around the cells of the superior olivary nuclei and trapezoid nuclei of both sides. Some fibres, however, pass directly into the lateral lemniscus of both sides.

The *lateral lemniscus* is thus formed by fibres from the superior olivary and trapezoid bodies of the same side as also of the other side together with the fibres coming uninterruptedly from the cochlear nuclei of both sides. Of these fibres of the lateral lemniscus some terminate around a nucleus called the *nucleus of the lateral lemniscus* situated higher up. Fresh fibres from this nucleus together with the remaining fibres of the lateral lemniscus terminate in the medial geniculate body and in the inferior colliculus. Fresh fibres from these bodies pass through the occipital part of the internal capsule to the middle third of the superior temporal gyrus and transverse temporal gyrus.

The **vestibular nerve** enters the brain on the medial side of and at a slightly higher level than the cochlear nerve. It proceeds backwards through the pons between the restiform body which lies lateral to it and the spinal tract of the trigeminal nerve which lies medial to it. Its fibres end in no less than five terminal nuclei. These nuclei are: (1) the *medial* or *principal nucleus*:

this is a large nuclear mass which is situated in the floor of the fourth ventricle subjacent to the area acustica; its upper part is crossed by the striæ medullares. (2) The *descending nucleus*: the fibres of the vestibular nerve divide into an ascending and a descending set; the latter passes downwards to the medulla oblongata as the descending tract of the vestibular nerve and end in grey substance, the nerve cells of which are scattered throughout it; this grey substance forms the descending nucleus. (3) The *lateral nucleus* or *Deiter's nucleus* lies close to the restiform body: the ascending fibres of the vestibular nerve end around the cells of the lateral nucleus. (4) The *superior nucleus*, also known as *Bechterew's nucleus*, lies close to the restiform body: it constitutes the upper part of the lateral nucleus and here also the ascending fibres end. (5) The *cerebellar nucleus*: some of the ascending fibres instead of terminating in the lateral and superior nuclei pass through the restiform body directly to the nucleus fastigius of the cerebellum or to its cortex. The fibres originating from the medial, superior, and lateral nuclei ascend through the medial longitudinal fasciculus and end in the nuclei of oculomotor, trochlear and abducent nerves while some accompany the fibres destined for the nucleus fastigius and the cerebellar cortex. Other fibres are believed to pass through the lateral lemniscus and reach the thalamus.

**Course of the acoustic nerve.**—From its superficial attachment to the brain, the nerve passes forwards across the posterior border of the brachium pontis accompanied by the facial nerve—the internal auditory artery intervenes between the two nerves. It then enters the internal acoustic meatus with the facial nerve; here it receives one or two filaments from the facial and then the trunk separates into its two original portions, the cochlear and vestibular.

The peripheral distribution of the *cochlear* and *vestibular nerves* are described in the Section on the Ear.

## The Glossopharyngeal Nerve

The **glossopharyngeal nerve** (Fig. 277) is a mixed nerve consisting of a smaller motor part and a larger sensory part. The motor part supplies the stylopharyngeus; the sensory part supplies (1) the mucous membrane of the posterior third of the tongue of which it is the nerve of taste as also of common sensation and (2) the mucous membrane of the pharynx, fauces and palatine tonsil. The nerve makes its superficial appearance in the form of three or four filaments in the upper part of the medulla oblongata in the groove between the restiform body and olive, and immediately below the facial nerve. The *sensory fibres* arise from the cells of the superior and petrous ganglia which are situated on the glossopharyngeal nerve as it passes through the jugular foramen. Entering the medulla oblongata the sensory fibres end in two terminal nuclei: some fibres terminate in a nucleus in the lower part of the rhomboid fossa beneath the ala cinerea ; others and by far the larger number of fibres descend along a tract called the *fasciculus solitarius* and end in the cells connected with this tract, the *nucleus tractus solitarii*. The *motor fibres* arise within the medulla oblongata as the axons of some of the cells of the *nucleus ambiguus* ; this nucleus is the combined nucleus of origin of the glossopharyngeal and vagus nerves situated in the floor of the fourth ventricle lateral to the nucleus of the hypoglossal nerve. From the nucleus ambiguus the fibres pass dorsalwards towards the rhomboid fossa, and then altering their course, pass forwards and lateralwards to unite with the sensory fibres.

**Course of the nerve.**—The filaments of the glossopharyngeal nerve emerge from the medulla oblongata immediately below the facial nerve and in series with the filaments of the vagus nerve below. The filaments unite to form a nerve which passes forwards and lateralwards and leaves the skull through the jugular foramen along with and in front of the vagus and accessory nerves. It is lodged in a bony canal within the jugular foramen and here it is enclosed in a tubular sheath of dura mater which separates it from the inferior petrosal sinus in front and the vagus and accessory nerves behind. After its exit from the skull it proceeds forwards between the internal jugular vein and internal carotid artery ; it then descends in front of the internal carotid artery, and, passing beneath the styloid process and the muscles attached to that process, it proceeds to the lower border of the stylopharyngeus. Thereafter it curves forwards over the stylopharyngeus and middle constrictor of the pharynx. Finally it runs beneath the hyoglossus to reach its termination in the tongue.

While passing through the jugular foramen two ganglia are noticed in connection with this nerve, viz., an upper called the superior ganglion (jugular ganglion) and a lower called the petrous ganglion. The **superior ganglion** is situated in the upper end of the bony canal containing the nerve and gives off no branch. The **petrous ganglion** is much larger and placed at the lower end of the jugular foramen. From the petrous ganglion branches of communication are given off (1) to the superior cervical ganglion of the sympathetic, (2) to the jugular ganglion of the vagus, and (3) to the auricular branch of the vagus. A communicating branch is given off from the glossopharyngeal nerve below the petrous ganglion which pierces the posterior belly of the digastricus and joins the facial nerve after its exit from the cranial cavity. The branches of distribution of the glossopharyngeal nerve are :—(1) tympanic, (2) pharyngeal, (3) nerve to the stylopharyngeus, (4) tonsillar, (5) lingual, and (6) carotid.

The **tympanic nerve** (Jacobson's nerve) arises from the petrous ganglion and reaches the tympanic cavity through the inferior tympanic canaliculus. Reaching the tympanic cavity it traverses its medial wall and lies in a groove on the surface of the promontory. Here it is joined by two branches, called the *superior* and *inferior caroticotympanic branches*, which issuing from the sympathetic plexus around the internal carotid artery in the carotid canal, enter the tympanic cavity through the bony wall of the canal and form a plexus called the *tympanic plexus*. Emerging from this plexus the tympanic nerve leaves the tympanic cavity at its anterior part and passes through a bony canal to enter the middle cranial fossa through a slit just lateral to the hiatus canalis facialis. In this bony canal it is joined by a filament from the genicular ganglion of the facial nerve and is then termed the *lesser superficial petrosal nerve*. From the cranial cavity it passes out through the foramen ovale or the canaliculus innominatus of Arnold and ultimately ends in the otic ganglion. The lesser superficial petrosal nerve contains parasympathetic fibres which constitute the parasympathetic root of the otic ganglion. In the tympanic cavity the tympanic nerve supplies filaments to the mucous membrane of the tympanic cavity and of the auditory tube and to the lining membrane of the mastoid cells.

The **pharyngeal branches** are three or four filaments which unite with the pharyngeal branches of the vagus and with the laryngo-pharyngeal branches of the sympathetic trunk to form the *pharyngeal plexus*. Filaments from this plexus supply the muscles of the pharynx and its mucous membrane.

The **nerve to the stylopharyngeus** supplies that muscle.

The **tonsillar branches** supply the palatine tonsil, the soft palate and the fauces.

The **lingual branches** supply the mucous membrane of the posterior third of the tongue and the anterior surface of the epiglottis.

The **carotid branches** proceed downwards along the internal carotid artery as low as the origin of the vessel.

## The Vagus Nerve

The **vagus nerve** (Figs. 278, 279) is a mixed nerve consisting of motor and sensory fibres. It has the most extensive distribution of all the cerebral nerves on account of its passing through the neck and thorax to the abdomen. It supplies motor fibres to (1) the muscles of the soft palate (except the tensor veli palatini), (2) the constrictor muscles of the pharynx, (3) the muscular tissue of the œsophagus, stomach, trachea and bronchi, and (4) the intrinsic muscles of the larynx. It supplies sensory fibres to the larynx, trachea, bronchial tubes, pharynx, œsophagus and stomach. The cardiac fibres of the vagus nerve are afferent (depressor) and efferent (inhibitory). The nerve makes its superficial appearance in the form of eight to ten filaments, below the filaments of the glossopharyngeal nerve, in the groove between the olive and restiform body of the medulla oblongata. The *sensory fibres* arise from the cells of the jugular ganglion and ganglion nodosum of the nerve. These fibres enter the medulla oblongata and terminate mostly at the lower part of a nucleus which lies beneath the ala cinerea in the lower part of the rhomboid fossa ; some of the sensory fibres descend along the tractus solitarius and arborize around the cells of this tract –the former constitutes the *dorsal nucleus of termination ;* the latter constitutes the *nucleus tractus solitarii* and is the other nucleus of termination. Thus the nucleus tractus solitarii is the combined nucleus of termination of the facial, glossopharyngeal and some of the fibres of the vagus nerve. The *motor fibres* arise as the axons of the motor cells of the *nucleus ambiguus* which is the nucleus of origin or motor nucleus of all the motor fibres of the glossopharyngeal and vagus nerves. From the nucleus ambiguus the motor fibres proceed to join the sensory fibres.

**Course of the nerve.**—The filaments of the nerve unite to form a single trunk which passes beneath the flocculus of the cerebellum to the jugular foramen and leaves the skull through the middle compartment of this foramen to enter the neck. *In the jugular foramen* it occupies the same sheath of duramater with the accessory nerve and is placed behind the glossopharyngeal nerve which is enclosed in a separate sheath ; in this foramen a small spherical ganglion, the **jugular ganglion** (ganglion of the root) is developed upon it.

**In the neck.**—Immediately below the jugular foramen there is a fusiform enlargement of the vagus nerve, about $\frac{3}{4}$ inch in length, called the **ganglion nodosum** (ganglion of the trunk) which is joined by the cerebral portion of the accessory nerve. The nerve descends vertically within the carotid sheath and lies between the internal carotid artery and internal jugular vein as far as the upper border of the thyreoid cartilage and then between the common carotid artery and the same vein up to the root of the neck. Within the carotid sheath it lies on a plane posterior to the artery and the vein. The further course and relations of the right and left vagus nerves differ from each other and require separate descriptions.

**In the thorax.**—The *right vagus nerve* descends in front of the first part of the subclavian artery, continues its course in the superior mediastinum behind the right innominate vein and superior vena cava and proceeding along the right side of the trachea, reaches the posterior aspect of the root of the right lung where it breaks up into several branches which are disposed in a plexiform manner and constitute the *posterior pulmonary plexus.* From the lower part of this plexus two cords (sometimes one) issue and descend upon the œsophagus upon which they give off several branches which unite with the corresponding branches of the left vagus nerve to form the *oesophageal plexus.* From this plexus the right vagus nerve issues as a single trunk which descends on the posterior surface of the œsophagus and enters the abdomen through the œsophageal opening of the diaphragm.

The *left vagus nerve* enters the thoracic cavity, between the left common carotid and the left subclavian arteries and descends in the superior mediastinum behind the left innominate vein.

Then it crosses the arch of the aorta, passes to the back part of the root of the left lung, where it breaks up into several branches which unite with filaments from the sympathetic trunk forming the *posterior pulmonary plexus.* From the lower part of this plexus two cords issue and descend upon the œsophagus and give off several branches which unite with the corresponding branches of the right vagus nerve forming the *œsophageal plexus.* From this plexus the left vagus nerve emerges as a single trunk which descends on the anterior surface of the œsophagus and enters the abdomen through the œsophageal opening of the diaphragm.

**In the abdomen.**—The *right vagus nerve,* passing behind the œsophagus, is distributed to the posteroinferior surface of the stomach and sends communicating offsets to the cœliac and lienal plexuses. The *left vagus nerve,* passing in front of the œsophagus, is distributed to the anterosuperior surface of the stomach and sends communicating offsets along its lesser curvature to the right vagus and between the layers of the lesser omentum to the hepatic plexus.

The **branches** and **communications** of the vagus nerve may be divided into four sets : (i) ganglionic, (ii) cervical (from the trunk), (iii) thoracic, and (iv) abdominal.

(i) **Ganglionic branches.**—The jugular ganglion gives off twigs which communicate with (1) the petrous ganglion of the glossopharyngeal nerve, (2) the accessory nerve, and (3) the superior cervical ganglion of the sympathetic. Two branches of distribution arise from the jugular ganglion, viz., the meningeal branch and the auricular nerve. The **meningeal branch** passes upwards through the jugular foramen to supply the dura mater in the posterior fossa of the skull. The **auricular nerve** (Arnold's nerve) is joined by a filament from the petrous ganglion of the glossopharyngeal nerve and passes backwards along the lateral surface of the internal jugular vein to enter the mastoid canaliculus on the lateral wall of the jugular fossa. Then it passes through the substance of the petrous portion of the temporal bone and crosses the facial canal above the stylomastoid foramen where it gives off a twig to communicate with the facial nerve. It then reaches the exterior of the skull by coming out through the tympanomastoid fissure and divides into two branches : one of which communicates with the posterior auricular branch of the facial nerve and the other supplies the posterior aspect of the auricula and the external acoustic meatus.

The ganglion nodosum gives off branches of communication to (1) the superior cervical ganglion of the sympathetic, (2) the loop between the first and second cervical nerves, and (3) the hypoglossal nerve. The branches of distribution given off from the ganglion nodosum are two in number, the pharyngeal branch and the superior laryngeal nerve. The **pharyngeal branch** passes downwards and forwards between the external and internal carotid arteries and, on the surface of the constrictor pharyngis medius, communicates with the pharyngeal branches from the glossopharyngeal and superior cervical ganglion of the sympathetic to form the *pharyngeal plexus*—filaments from this plexus supply the muscles of the pharynx and soft palate (except the stylopharyngeus and tensor veli palatini) and the mucous membrane of the pharynx.

The **superior laryngeal nerve** passes downwards and medialwards behind the internal carotid artery and divides into the external and internal laryngeal branches. The *external laryngeal branch* is a long slender filament which passes downwards beneath the sternothyreoid muscle and supplies the cricothyreoideus and the inferior constrictor of the pharynx. The *internal laryngeal branch* passes between the middle and inferior constrictor muscles of the pharynx and, piercing the hyothyreoid membrane in company with the superior laryngeal artery, is distributed to the mucous membrane of the larynx. It supplies twigs to the epiglottis, base of the tongue and sends a filament which runs beneath the lamina of the thyreoid cartilage and communicates with the recurrent nerve.

(ii) **Cervical branches.**—In the neck the trunk of the vagus nerve gives off (1) the recurrent nerve on the right side called the right recurrent nerve, and (2) the cervical or superior cardiac branches.

The **right recurrent nerve** arises at the root of the neck as the vagus crosses in front of the first portion of the subclavian artery. Winding round that artery it passes upwards and medialwards behind the subclavian, common carotid and inferior thyreoid arteries; thereafter it ascends in the groove between the trachea and œsophagus and along the medial aspect of the right lobe of the thyreoid gland. At the level of the cricoid cartilage it passes beneath the inferior constrictor of the pharynx and enters the larynx behind the cricothyreoid joint. Its *extralaryngeal branches* are: (1) *communicating twigs* to the inferior cervical ganglion of the sympathetic; (2) *cardiac branches* which arise when the nerve winds round the subclavian artery and run downwards along the trachea to the deep cardiac plexus; (3) the *tracheal* and *oesophageal branches* which supply these tubes, and (4) *muscular twigs* to the inferior constrictor of the pharynx. The *intralaryngeal branches* are mainly muscular and supply the intrinsic muscles of the larynx except the cricothyreoideus; the sensory branches supply the mucous membrane of the larynx.

The **cervical** or **superior cardiac branches** are two in number, an upper and a lower. *On the right side* both the upper and lower branches pass into the thorax behind the subclavian artery and run along the side of the trachea to join the deep cardiac plexus. *On the left side* the upper branch passes along the side of the trachea to join the deep cardiac plexus. The lower branch descends in company with the vagus over the aortic arch and joins the superficial cardiac plexus.

(iii) **Thoracic branches.**—In the thorax the vagus nerve gives off (1) the thoracic or inferior cardiac branches, (2) the left recurrent nerve, (3) the anterior pulmonary, (4) posterior pulmonary, and (5) œsophageal branches.

The **thoracic** or **inferior cardiac branches** on the right side arise from the trunk of the vagus as it lies beside the trachea and from its recurrent nerve; on the left side they arise from the recurrent nerve. They join the deep cardiac plexus.

The **left recurrent nerve** arises from the vagus as it crosses the aortic arch. It winds round the aortic arch lateral to the ligamentum arteriosum and turns upwards behind the arch to reach the side of the trachea. The course and relations of the remaining part of the nerve are similar to those of the right recurrent nerve. The branches of the nerve are the same as those of the right nerve with this difference that the cardiac branches arise below the aortic arch.

The **anterior pulmonary branches** are two or three filaments, which pass to the anterior aspect of the root of the lung, unite with filaments from the sympathetic trunk and form the *anterior pulmonary plexus.*

The **posterior pulmonary branches** are several large filaments which join with branches from the third and fourth ganglia of the sympathetic trunk forming the *posterior pulmonary plexus.* Filaments are given off from this plexus to supply the bronchi and lungs.

The **oesophageal branches** join with the branches from the opposite nerve and form the *oesophageal plexus* which supplies the œsophagus and the back part of the pericardium.

(iv) **Abdominal branches.**—In the abdomen the vagus nerve gives off (1) gastric, (2) cœliac, and (3) hepatic branches. The **gastric branches** of the right vagus are distributed on the postero-inferior surface of the stomach and form the *posterior gastric plexus;* those of the left vagus are distributed on the antero-superior surface of the stomach and form the *anterior gastric plexus.* The **coeliac branches** end in the cœliac plexus. The **hepatic branches** end in the hepatic plexus.

## The Accessory Nerve

The **accessory nerve** (spinal accessory nerve) (Figs. 128, 278) consists of two separate parts, cerebral and spinal, which differ both in origin and distribution. The **cerebral** or **bulbar portion** is accessory to the vagus nerve. Its fibres arise from the nucleus ambiguus and appear on the surface of the brain as four or five filaments below those of the vagus on the side of the medulla oblongata. In the jugular foramen these filaments either unite with the spinal portion to form one trunk or freely intermingle and a communication is established between it and the jugular ganglion of the vagus by two twigs. The nerve passes through the jugular foramen being enclosed in the same sheath with the vagus and immediately beneath the jugular foramen the two parts of the nerve separate. The cerebral portion passes over and lies in intimate contact with the ganglion nodosum of tho vagus and its fibres are continued mainly to the pharyngeal and superior laryngeal branches of the ganglion nodosum while some fibres are continued into the trunk of the vagus below this ganglion. These latter fibres ultimately enter the cardiac and recurrent branches of the vagus. Thus, the cerebral portion is regarded as the motor nerve of the intrinsic muscles of the larynx, the muscles of the soft palate (except the tensor veli palatini) and the constrictor muscles of the pharynx ; it also supplies inhibitory fibres to the heart.

The **spinal part** arises from the lateral part of the anterior column of grey substance of the medulla spinalis as low as the origin of the fifth cervical nerve. Its fibres pass through the lateral funiculus of the medulla spinalis and emerge on its lateral aspect between the anterior and posterior roots of the cervical nerves. These fibres successively join together to form a single trunk which ascends posterior to the ligamentum denticulatum and enters the skull through the foramen magnum. The trunk then passes to the jugular foramen where it either unites with the cerebral portion to form one common trunk or freely intermingle. Beneath the jugular foramen the spinal portion separates and runs backwards and downwards either behind or in front of the internal jugular vein and descends obliquely under cover of the digastricus and stylohyoideus. It pierces the deep surface of the sternocleidomastoideus which it supplies and appears at the posterior border of the muscle at about the level of the upper border of the thyreoid cartilage. Thereafter it crosses the posterior triangle of the neck obliquely downwards and backwards and terminates by supplying the trapezius on its deep surface. This portion of the nerve communicates with (1) in or beneath the sternocleidomastoideus with the branch for the muscle derived from the second cervical nerve ; (2) in the posterior triangle with the branches from the third and fourth cervical nerves ; (3) beneath the trapezius with the branches for the muscle derived from the third and fourth cervical nerves forming a plexus.

## The Hypoglossal Nerve

The **hypoglossal nerve** (Figs. 277, 278) is a purely motor nerve and supplies the extrinsic and intrinsic muscles of the tongue. Its fibres arise from the axons of the cells of the *hypoglossal nucleus* which is situated in the substance of the medulla oblongata. This nucleus is elongated, about ¾th inch in length and extends superiorly to the level of the striæ medullares and inferiorly to a point just above the decussation of the pyramids. The superior part of the nucleus is situated within the upper open or ventricular part of the medulla oblongata and corresponds with the trigonum hypoglossi ; the inferior part is placed within the lower or closed part of the medulla oblongata and lies in the grey substance which forms the ventrolateral aspect of its central canal. The fibres traverse the entire anteroposterior thickness of the medulla and make their superficial appearance on the surface of the medulla oblongata in the anterolateral sulcus between the pyramid and olive. The filaments of the nerve

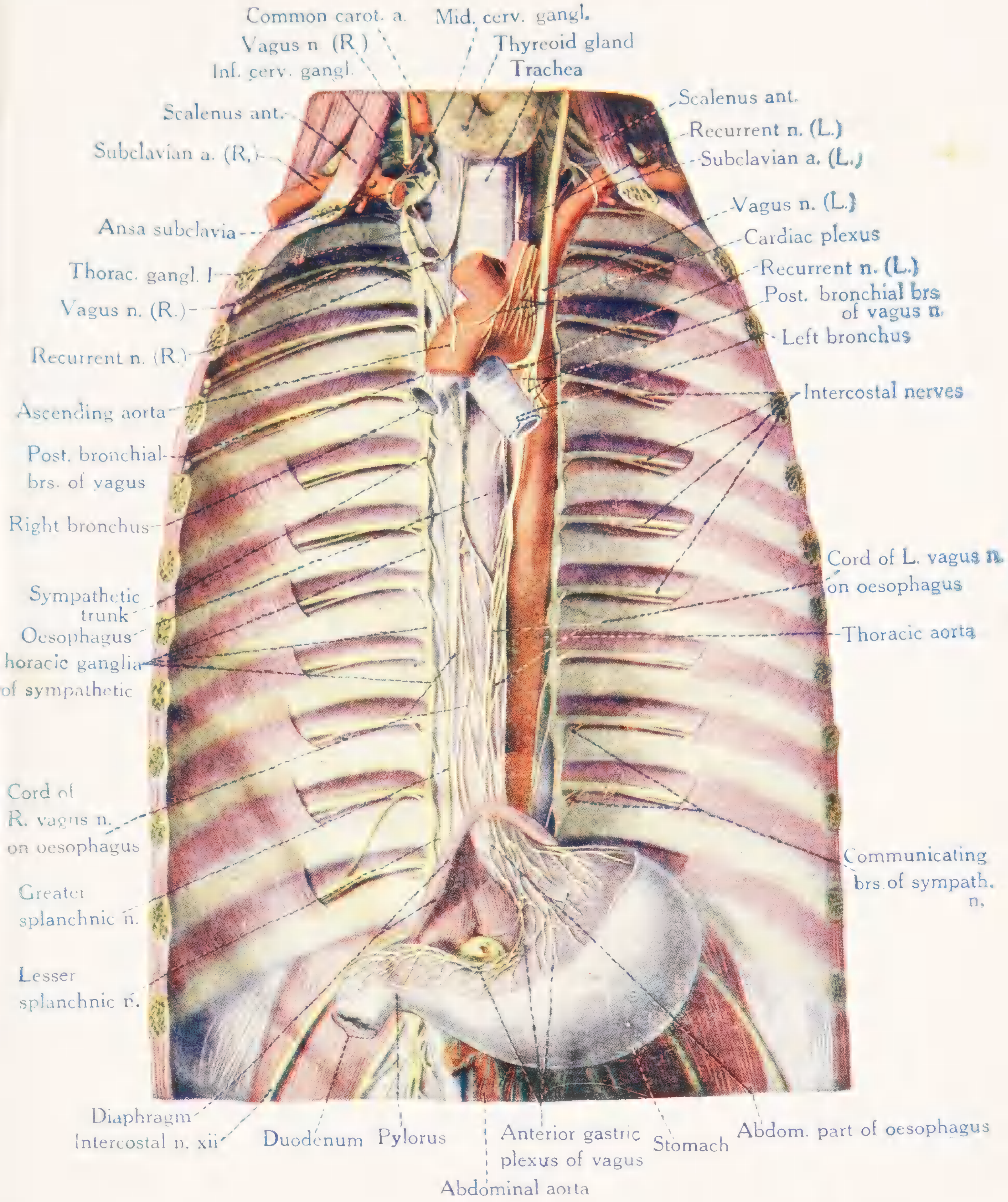


Fig. 279.—The course and distribution of the right and left vagns nerves.

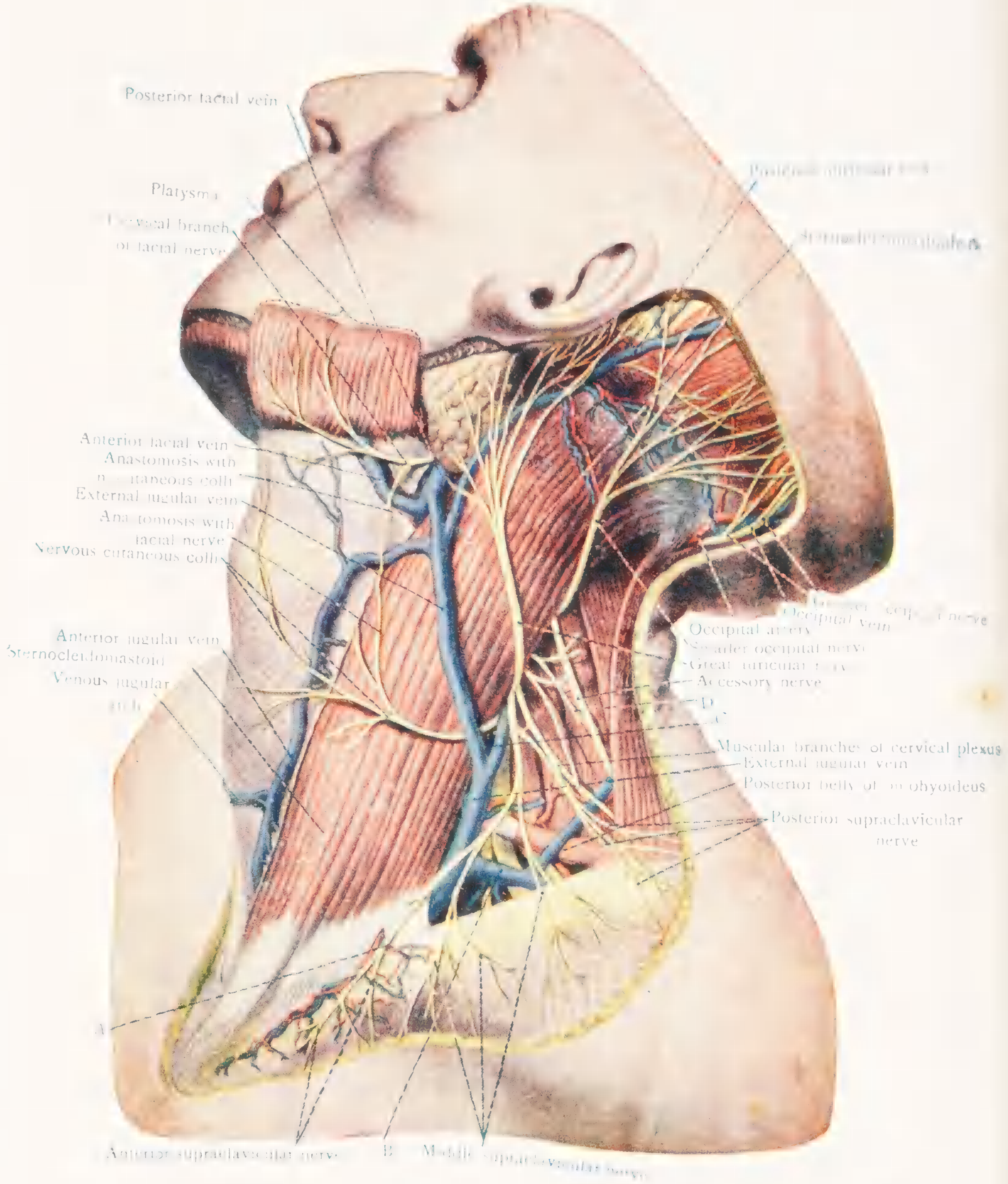


Fig. 282.—Superficial dissection of the triangles of the neck.

(See p. 588)

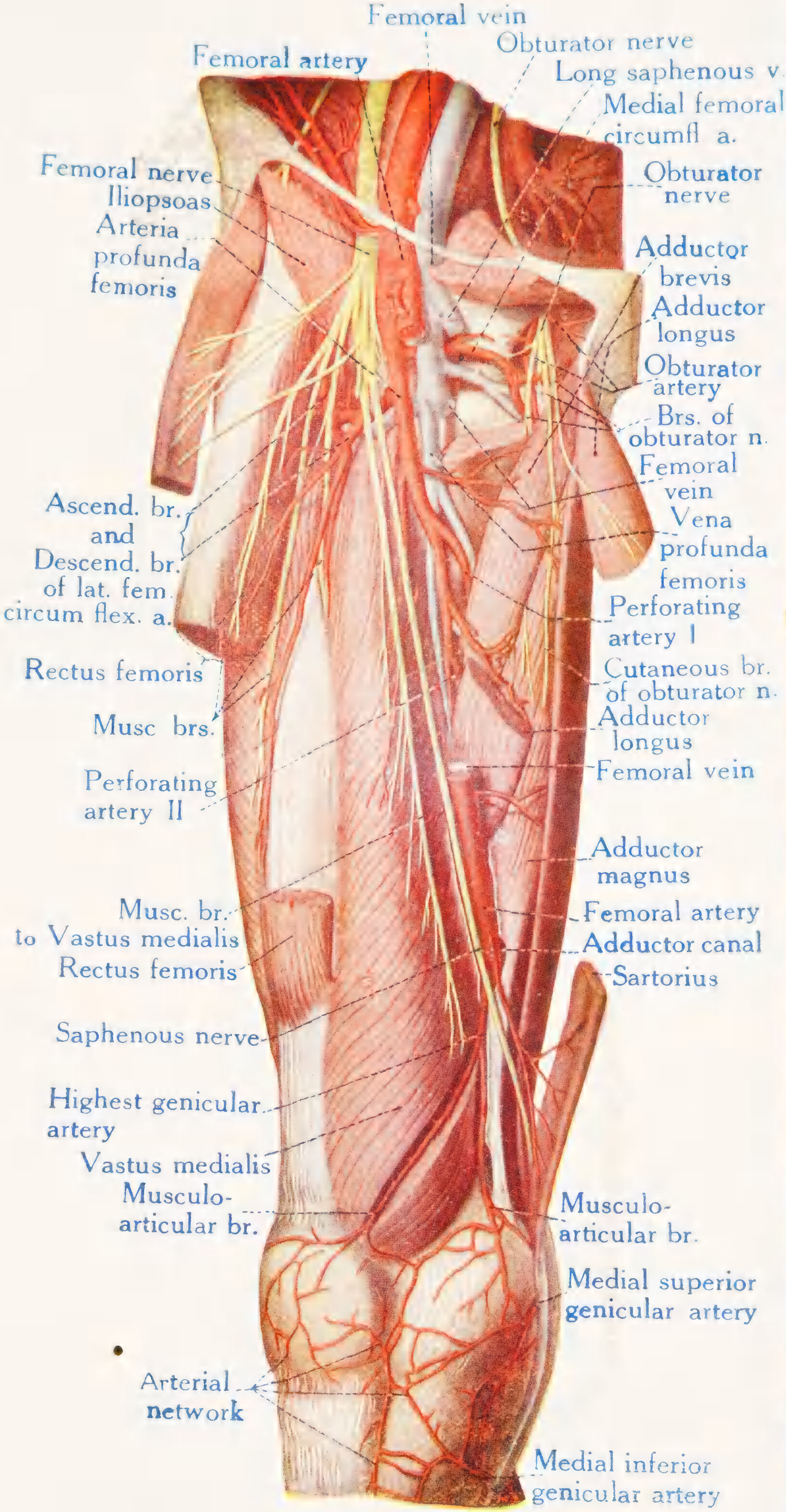


Fig. 288.—Deep dissection of the front of the thigh.

(See p. 608).

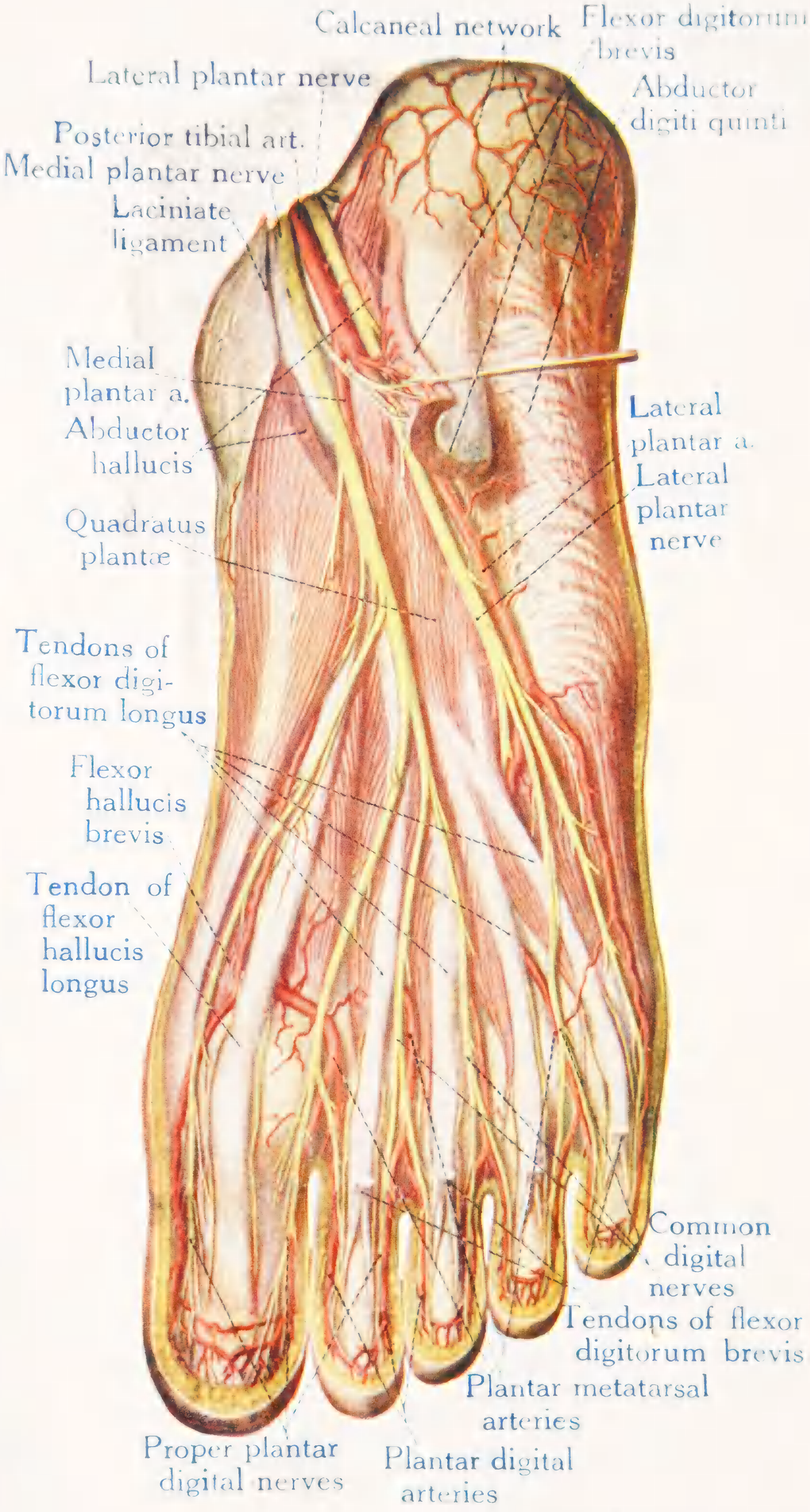


Fig. 291.—Dissection of the sole of the foot

( See p. 617 ).

To face p. 581

arrange themselves into two bundles which separately pierce the dura mater opposite the hypoglossal canal of the occipital bone and unite to form a single trunk in this canal or after emerging from the skull.

**Course of the nerve.**—After its exit from the canal the nerve is very deeply placed under cover of the internal jugular vein and the internal carotid artery. It next passes downwards and forwards behind the ganglion nodosum of the vagus with which it is closely connected. Then it proceeds between the internal jugular vein and the internal carotid artery till it reaches the lower border of the posterior belly of the digastric, and winding round the occipital artery, turns transversely forwards to cross the external carotid artery and the first part of the lingual artery. It next passes deep to the tendon of the digastricus and stylohyoideus and superficial to the hyoglossus. After this it disappears deep to the mylohyoideus but still lying upon the hyoglossus. Finally it runs forwards in the substance of the genioglossus as far as the tip of the tongne.

The **communications** of the hypoglossal nerve are : near the base of the skull—(1) with the superior cervical ganglion of the sympathetic, (2) with the ganglion nodosum of the vagus, (3) with the loop between the first two cervical nerves ; as the nerve winds round the occipital artery—(4) with the pharyngeal plexus ; at the anterior border of the hyoglossus—(5) with the lingual branch of the mandibular nerve. The hypoglossal nerve receives many spinal fibres—these fibres become applied to the nerve ; some fibres quit the nerve to form the descending branch which is thus of spinal, and not hypoglossal origin ; other fibres continue along the main trunk.

The **branches** of the hypoglossal nerve are : (1) meningeal, (2) descending, (3) thyreohyoid, and (4) muscular.

The **meningeal branch** arises in the hypoglossal canal, takes a recurrent course and supplies the dura mater in the posterior fossa of the skull. It derives its fibres from the communication with the first and second cervical nerves.

The **descending branch** issues as the hypoglossal nerve hooks round the occipital artery. It descends in front of or is embedded in the anterior wall of the carotid sheath. Reaching the middle of the neck it joins the descendens cervicalis which is formed by the union of the communicantes cervicales to form a loop called *ansa hypoglossi* (*hypoglossal loop*). Before forming the loop it gives a twig to the superior belly of the omohyoid and from the loop itself branches are given off to the inferior belly of the omohyoid, sternohyoid, and sternothyreoid muscles. The ansa derives its fibres from the first three cervical nerves.

The **thyreohyoid branch** issues from the hypoglossal near the posterior border of the hyoglossus. It descends behind the greater cornu of the hyoid bone and is distributed to the thyreohyoideus. Its fibres are associated with those of the loop between the first and second cervical nerves.

The **muscular branches** supply the styloglossus, hyoglossus, geniohyoid, and genioglossus and all the intrinsic muscles of the tongue. It is believed that the branches to these muscles derive their fibres from the cervical nerves.

## THE SPINAL NERVES

Thirty-one pairs of spinal nerves arise from the medulla spinalis and are grouped as follows : eight pairs cervical, twelve pairs thoracic, five pairs lumbar, five pairs sacral, and one pair coccygeal.

**Mode of exit.**—As a rule each spinal nerve in the cervical, thoracic and lumbar regions issues out of the vertebral canal through the intervertebral foramen and the sacral nerves through the sacral foramina. But there are exceptions : thus the first cervical nerve passes out between the occipital bone and the atlas and is called the *suboccipital nerve ;* the second cervical nerve passes out across the arch of the epistropheus ; and the fifth sacral nerve and the coccygeal nerve come out through the lower opening of the sacral canal.

**Nerve roots.**—Each spinal nerve is formed by two roots, an anterior or motor root and a posterior or sensory root. The *anterior root* issues from the anterior surface of the medulla spinalis by several filaments which are spread out rather irregularly at the attached area but unite to form two bundles near the intervertebral foramen. The *posterior root* is larger than the anterior—except in the first cervical nerve where it is smaller than the anterior root ; its filaments are attached in a regular line to the posterolateral fissure of the medulla spinalis ; these unite to form two bundles which end in the spinal ganglion.

**Spinal ganglion and its situation.**—A swelling, called the spinal ganglion, is seen on each of the posterior roots within the intervertebral foramen before its union with the anterior root. As a rule the ganglion is placed within the intervertebral foramen and the union of the anterior and posterior roots takes place within the same foramen. But there are certain exceptions to this : thus the ganglia on the posterior roots of the first two cervical nerves lie on the vertebral arches of the atlas and epistropheus ; the ganglion on the posterior roots of the sacral nerves are developed within the sacral canal and the union of their anterior and posterior roots also takes place within the same canal. The ganglion on the posterior root of the coccygeal nerve is developed before it pierces the dura mater and its two roots blend within the sacral canal.

**Size and direction of nerve roots.**—The roots of the upper cervical nerves are short and directed transversely lateralwards. The roots of the lower cervical and the thoracic nerves are directed obliquely downwards ; the obliquity and length of the successive nerves increase from above downwards. The roots of the lumbar, sacral and coccygeal nerves are very long and directed vertically downwards around the medulla spinalis ; these nerve roots form a bundle in the lower part of the vertebral canal below the first lumbar vertebra and constitute what is known as the *cauda equina*. In the case of the lower thoracic nerves the length of the roots is equal to the depth of two vertebræ and the length of each successive root of the lumbar and sacral nerves gradually increases on account of the fact that the medulla spinalis does not extend beyond the first lumbar vertebra.

**Formation of spinal nerve trunks and their divisions.**—Each spinal nerve is formed by the blending of the anterior and posterior roots immediately beyond the spinal ganglion. The spinal nerve trunk is very short and immediately divides into an anterior and a posterior division. The spinal nerve trunks of the sacral and coccygeal nerves are however longer and their division takes place within the sacral canal. A minute branch, called the *ramus meningeus,* is given off from each spinal nerve after its exit from the intervertebral foramen and immediately before it splits into an anterior and a posterior division ; this branch again enters the vertebral canal through the intervertebral foramen and unites with a filament from the sympathetic trunk. It supplies the vertebræ, their periosteum and the meninges of the medulla spinalis.

**Connections with the sympathetic.**—After its exit from the intervertebral foramen, each spinal nerve gives off a branch, *white ramus communicans* to the neighbouring sympathetic ganglion in the case of the thoracic and first and second lumbar nerves. But each spinal nerve without exception receives a branch, *grey ramus communicans* from a neighbouring sympathetic ganglion.

**Relation to the meninges.**—Within the vertebral column each nerve root is in relation with the meninges of the medulla spinalis. Each receives a covering of the pia mater and is invested by the arachmoid as far as the point where the root pierces the dura mater. Beyond this point the two roots are enclosed in a single sheath of dura mater and when the spinal nerve is formed this sheath becomes continuous with the epineurium of the nerve.

**Spinal segments or neuromeres.**—These are portions of the medulla spinalis, the length of each of which is equal to the extent of attachment of a pair of spinal nerves.

**Areas of distribution of spinal nerves.**—The spinal nerves have primarily a segmental distribution but owing to developmental changes in the parts supplied, the segmental distribution is not only obscured but becomes obliterated in some nerves. It is only in the trunk that this segmental distribution is greatly retained and also in the areas supplied by the posterior primary divisions. In the case of the limbs and head the distribution is extremely variable merging into obscurity in many instances. The cutaneous nerves of the posterior primary divisions more nearly supply definitely prescribed areas than the muscular branches of these divisions. At the same time it should be understood that no nerve, cutaneous or muscular, has a definite area of distribution because the adjacent nerves encroach upon this area.

**Structure.**—A spinal nerve contains fibres derived from the somatic and autonomic systems. The somatic fibres are afferent and efferent. The afferent fibres arise from the unipolar cells of the spinal ganglion ; the efferent fibres arise from the cells of the anterior column of grey substance of the medulla spinalis and pass to the spinal nerves through the anterior nerve roots. The autonomic fibres are also afferent and efferent. The afferent fibres arise from the cells of the spinal ganglion and pass through the white ramus communicans and then through the sympathetic ganglion to be distributed to an organ ; the efferent fibres arise from the lateral column of the medulla spinalis and pass through the anterior nerve root to end in a sympathetic ganglion.

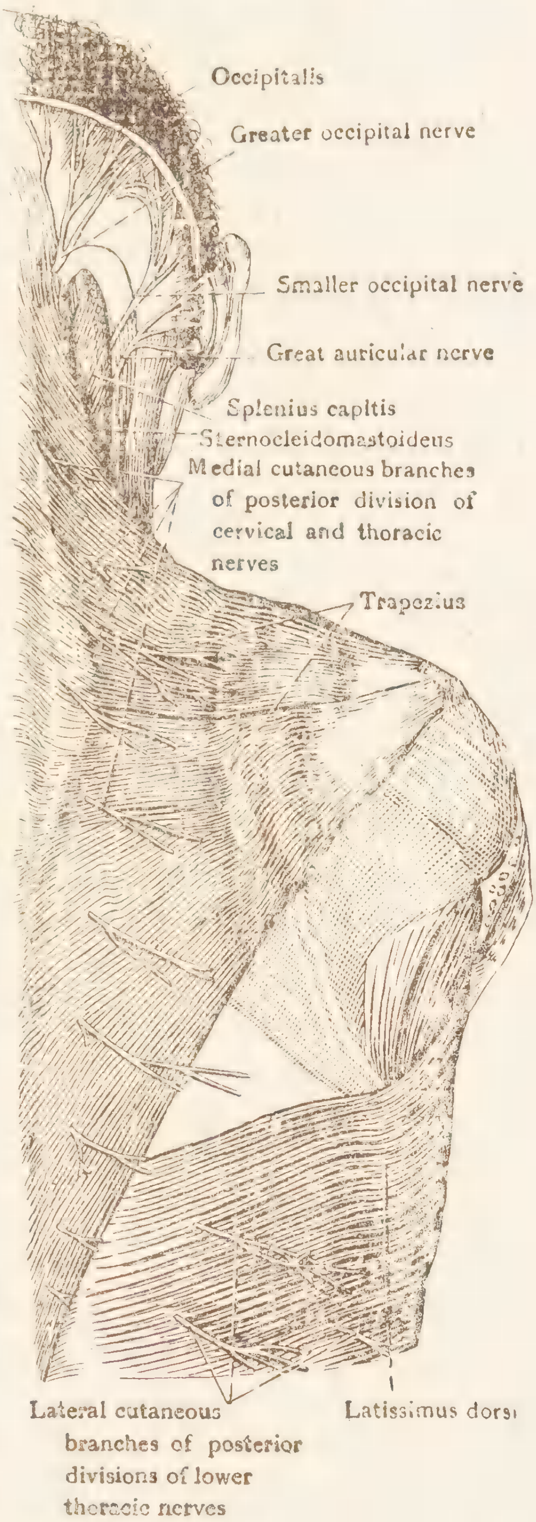
### The Posterior Divisions of the Spinal Nerves

The **posterior divisions of the spinal nerves** (Fig. 280) appear at the back between the transverse processes in the cervical, thoracic and lumbar regions and are smaller than the anterior divisions (excepting the first two cervical nerves). With the exception of four nerves (the first cervical, the fourth and fifth sacral and the coccygeal) each posterior division divides into a medial and a lateral branch. As a general rule it may be said that the medial branches of the posterior divisions of the cervical and first six thoracic nerves supply muscles and then become cutaneous to supply the skin ; whereas the lateral branches of these nerves supply the muscles and do not become cutaneous. From the seventh thoracic nerve downwards the distribution of the posterior divisions is reversed, viz., the lateral branches supply the muscles and integument as well ; whereas the medial branches supply the muscles only and do not become cutaneous.

**Posterior divisions of the cervical nerves.**—The posterior division of the *first cervical* or *suboccipital nerve* is purely muscular. It emerges above the posterior arch of the atlas and beneath the vertebral artery. It does not divide into medial and lateral branches but passes to the suboccipital triangle and at once breaks up into branches which supply the three muscles viz., rectus capitis posterior major and obliquii capitis, superior and inferior, which form the boundaries of that triangle, and the rectus capitis posterior minor and semispinalis capitis. The posterior division of the *second cervical nerve* is very large. It passes backwards between the posterior arch of the atlas and lamina of the epistropheus and gives off a twig to the obliquus capitis inferior. Its medial branch is very long and is called the *greater occipital nerve* ; it pierces the semispinalis capitis and trapezius near the superior nuchal line of the occipital bone and runs upwards on the back of the head lying close to the occipital artery and divides into many branches which supply the skin over the back part of the head as far forwards as the vertex.

Sometimes it gives off an auricular branch which supplies the skin over the back part of the ear. Its lateral branch supplies the splenius, longus capitis, and semispinalis capitis. The medial branch of the posterior division of the *third cervical nerve* gives off a cutaneous branch called the *third occipital nerve* which ascends to the scalp medial to the greater occipital nerve; its lateral branch joins with that of the second cervical. The posterior division of the suboccipital nerve and the medial branches of the posterior divisions of the second and third cervical nerves communicate by loops forming the *posterior cervical plexus.* The medial branches of the *fourth* and *fifth cervical nerves* become cutaneous by piercing the trapezius near the spinous processes; those of the *sixth, seventh* and *eighth cervical nerves* are exhausted in supplying the muscles (semispinalis cervicis, semispinalis capitis, multifidus and interspinalis) and do not become cutaneous. The lateral branches of the posterior divisions of the lower five cervical nerves supply the iliocostalis cervicis, longissimus cervicis and longissimus capitis muscles and do not become cutaneous.

**Posterior divisions of the thoracic nerves.**—The medial branches of the posterior divisions of the upper six thoracic nerves supply the multifidus and sacrospinalis and become cutaneous by piercing the trapezius near the spinous processes; those of the lower six nerves are exhausted in supplying the multifidus. The lateral branches of the upper six thoracic nerves supply the lateral and intermediate prolongations of the sacrospinalis and do not become cutaneous; those of the lower six nerves supply the muscles and become cutaneous by emerging in a line with the angles of the ribs. The lateral branches of the eleventh and twelfth nerves pass over the iliac crest to the skin of the anterior part of the buttock.


Occipitalis
Greater occipital nerve
Smaller occipital nerve
Great auricular nerve
Splenius capitis
Sternocleidomastoideus
Medial cutaneous branches of posterior division of cervical and thoracic nerves
Trapezius
Lateral cutaneous branches of posterior divisions of lower thoracic nerves
Latissimus dorsi

Fig, 280.—The cutaneous branches of the posterior divisions of the spinal nerves.

**Posterior divisions of the lumbar nerves.**—The medial branches of these nerves supply the multifidus. The lateral branches of the upper three nerves are large. They supply the sacrospinalis, pierce the posterior lamella of the lumbodorsal fascia and descend across the iliac crest to become cutaneous in the gluteal region. The lateral branches of the fourth and fifth lumbar nerves supply the muscles and give off no cutaneous branches.

**Posterior divisions of the sacral nerves.**—The upper three emerge from the posterior sacral foramina and divide into medial and lateral branches. The medial branches end in the multifidus. The lateral branches form loops with each other. From these loops twigs are given off which pierce the sacrotuberous ligament and the glutæus maximus to supply the skin of the gluteal region. The posterior division of the fourth sacral nerve emerges from the fourth posterior sacral foramen, while that of the fifth sacral nerve, from the lower end of the sacral canal. These two nerves do not divide into medial and lateral branches but communicate with each other and with the third sacral above and the coccygeal nerve below. They supply the skin over the lower part of the sacrum and the back of the coccyx.

The **posterior division of the coccygeal nerve** emerges from the lower end of the sacral canal and does not divide into a medial and a lateral branch. It communicates with the fifth sacral nerve above and supplies the back of the coccyx.

### The Anterior Divisions of the Spinal Nerves

The **anterior divisions of the spinal nerves** are much larger (except the first two cervical nerves) than the corresponding posterior divisions. They are distributed to the anterior and lateral aspects of the trunk and limbs. The anterior divisions of the cervical, lumbar, sacral, and coccygeal nerves unite with one another to form plexuses but the anterior divisions of the thoracic nerves, except the first and last, remain separate and pursue independent courses.

### The Anterior Divisions of the Cervical Nerves

The anterior divisions of the upper four cervical nerves unite to form the cervical plexus by means of which the head and neck is supplied—each receives a grey ramus communicans from the superior cervical ganglion of the sympathetic ; those of the lower four together with the greater portion of the anterior division of the first thoracic nerve unite to form the brachial plexus by means of which the superior extremity is supplied—of these the fifth and sixth each receives a grey ramus communicaus from the middle cervical ganglion and the seventh and eighth, from the inferior cervical ganglion of the sympathetic trunk.

The anterior division of the **first cervical** or **suboccipital nerve** emerges by passing over the posterior arch of the atlas and curves forwards round the lateral side of the superior articular process of that bone medial to the vertebral artery. It then descends to form a loop with the ascending branch of the second cervical nerve. In its course it supplies a twig to the rectus capitis lateralis and some of its fibres join the hypoglossal nerve.

The anterior division of the **second cervical nerve** emerges between the neural arches of the atlas and epistropheus behind the superior articular process of the latter bone. It curves forwards lateral to the vertebral artery and divides into an ascending and a descending branch—the former unites to form a loop with the first cervical and some of its fibres join the hypoglossal nerve; the latter joins the ascending branch of the third cervical nerve.

## The Cervical Plexus

The **cervical plexus** (Figs. 278, 281, 282) is formed by the anterior divisions of the upper four cervical nerves and lies between the sternocleidomastoideus in front and the levator scapulæ and scalenus medius behind. The anterior divisions of the second, third and fourth cervical nerves divide each into an ascending and a descending branch which unite with each other forming loops. The ascending branch of the second cervical nerve joins the undivided anterior division of the first cervical nerve above while the descending branch of the fourth cervical nerve, joins the fifth nerve below to enter into the formation of the brachial plexus. The cervical plexus consists of three loops; the first loop is formed by the first and second cervical nerves; the second loop by the second and third nerves; and the third loop by the third and fourth nerves. The **branches** of the cervical plexus may be classified as follows:—

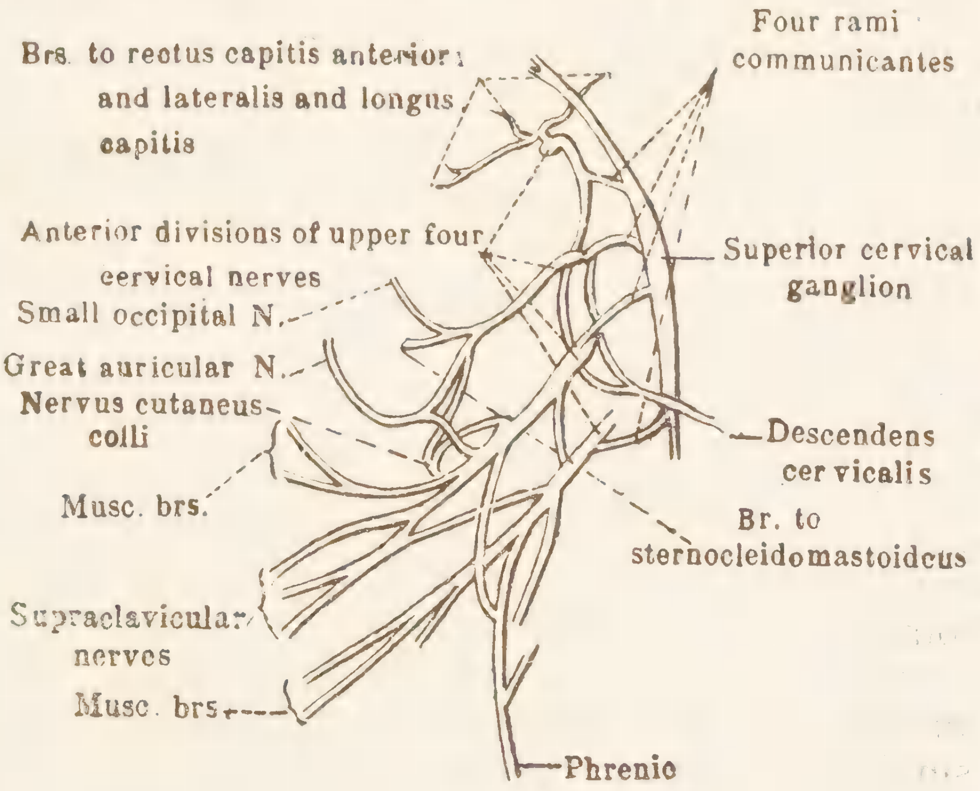

Brs. to rectus capitis anterior and lateralis and longus capitis
Four rami communicantes
Anterior divisions of upper four cervical nerves
Superior cervical ganglion
Small occipital N.
Great auricular N.
Nervus cutaneus colli
Descendens cervicalis
Musc. brs.
Br. to sternocleidomastoideus
Supraclavicular nerves
Musc. brs.
Phrenic

Fig. 281.—Diagram of the cervical plexus.

| | | | |
|---|---|---|---|
| Superficial | Ascending | Small occipital, C. 2. | |
| | | Great auricular, C. 2, 3. | |
| | Transverse | Cutaneous colli, C. 2, 3. | |
| | Descending | Anterior supraclavicular, | C. 3, 4. |
| | | Middle supraclavicular, | |
| | | Posterior supraclavicular, | |

| | | | | |
|---|---|---|---|---|
| Deep | Medial | Muscular | Rectus capitis anterior | C. 1, 2 |
| | | | Rectus capitis lateralis | C. 1, 2 |
| | | | Longus capitis | C. 1, 2 |
| | | | Longus colli | C. 2, 3, 4 |
| | | | Communicantes cervicales | C. 2, 3 |
| | | | Phrenic | C. 3, 4, 5 |
| | | Communicating | With vagus | C. 1, 2 |
| | | | With hypoglossal | C. 1, 2 |
| | | | With sympathetic | C. 1, 2, 3, 4 |
| | Lateral | Muscular | Sternocleidomastoideus | C. 2 |
| | | | Scalenus medius | C. 3, 4 |
| | | | Trapezius | C. 3, 4 |
| | | | Levator scapulæ | C. 3, 4 |
| | | Communicating | With accessory | C. 2, 3, 4 |

**Superficial branches of the cervical plexus** (Fig. 282).—These emerge at the posterior border of the sternocleidomastoideus at about its middle and may be grouped into (1) ascending branches viz., the smaller occipital nerve and the great auricular nerve, (2) transverse branch viz., cutaneous colli, and (3) the descending branches viz., the supraclavicular nerves.

The **smaller occipital nerve** is derived from the anterior division of the second cervical nerve. It runs upwards along the posterior border of the sternocleidomastoideus pierces the deep fascia and divides into mastoid, occipital and auricular branches. The mastoid and occipital branches supply the scalp ; the auricular branch supplies the cranial surface of the auricula. The nerve communicates with the greater occipital and great auricular nerves and also with the posterior auricular branch of the facial nerve.

The **great auricular nerve** is derived from the anterior divisions of the second and third cervical nerves. It crosses the sternocleidomastoideus obliquely and runs upwards towards the ear. It divides into two branches, an anterior and a posterior. The *anterior branch* passes through the substance of the parotid gland where it communicates with the facial nerve ; it supplies the skin over the parotid gland. The *posterior branch* supplies the skin over the mastoid process and back of the ear ; it communicates with the small occipital nerve.

The **nervus cutaneous colli** (transverse cervical nerve) is derived from the anterior divisions of the second and third cervical nerves. It passes forwards to the anterior triangle of the neck crossing the sternocleidomastoideus horizontally at about its middle under cover of the platysma and external jugular vein. In the anterior triangle it perforates the deep fascia and divides into ascending and descending branches. The *ascending branches* communicate with the cervical branch of the facial nerve and perforating the platysma, supply the skin of the submaxillary region. The *descending branches* pass downwards, pierce the platysma and supply the skin at the lower and front part of the neck.

The **supraclavicular nerves** originate from a single trunk derived from the anterior divisions of the third and fourth cervical nerves. This trunk appears beneath the posterior border of the sternocleidomastoideus at about its middle and soon divides into three branches, viz., anterior, middle and posterior supraclavicular nerves. The *anterior supraclavicular nerves* (suprasternal branches) run downwards and medialwards, pierce the deep fascia above the clavicle and crossing the medial third of the bone supply the skin over the sternum. While crossing the sternal end of the clavicle they furnish one or two twigs to supply the sternoclavicular articulation. The *middle supraclavicular nerves* (supraclavicular branches) pierce the deep fascia above the clavicle and cross its middle third to supply the skin over the pectoralis major and deltoideus. The *posterior supraclavicular nerves* (supraacromial branches) pierce the deep fascia at a higher level than the other supraclavicular nerves and descend over the trapezius and the acromion to supply the skin over the upper and back parts of the shoulder.

The **deep branches of the cervical plexus** are differentiated into a medial and a lateral set according to their relation with the sternocleidomastoideus. Beneath this muscle the *medial branches* are directed medially towards the anterior triangle while the *lateral branches* are directed laterally towards the posterior triangle. Communicating branches are given off both from the medial and the lateral set.

### Deep Branches—Medial Set

**Muscular branches.**—The rectus capitis anterior, rectus capitis lateralis and longus capitis are supplied from the loop formed by the first and second cervical nerves. These twigs pass medialwards to supply the muscles. The longus colli is supplied from the second, third, and fourth cervical nerves.

The **communicantes cervicales** consist of two branches, one from the second and the other from the third cervical nerve. These two branches unite to form the *descendens cervicalis* which descends lateral to the internal jugular vein, unites with the descending branch of the hypoglossal nerve, and forms a loop, *ansa hypoglossi,* in front of the carotid sheath.

The **phrenic nerve** (Figs. 205, 278) arises chiefly from the fourth cervical nerve, but it receives a filament from the third and another from the fifth cervical nerve. It is formed at the lateral margin of the scalenus anterior and crosses the muscle obliquely from the lateral to the medial side and then descends to the root of the neck. In its course in the neck it is covered by the sternocleidomastoideus, the inferior belly of the omohyoideus, the transverse cervical and transverse scapular vessels. At the root of the neck it passes between the subclavian artery and vein and enters the superior mediastinum by crossing the internal mammary artery near the origin of the vessel. It then runs vertically downwards in the middle mediastinum, lying by the side of the pericardium and in front of the root of the lung; here it is accompanied by the pericardiacophrenic branch of the internal mammary artery. It then reaches the upper surface of the diaphragm where it breaks up into branches which pierce the muscle and are distributed on its inferior surface.

The phrenic nerves of the two sides differ from each other in their course, relations and length. The *right phrenic nerve* is placed more deeply, and is more vertical in its course; at the root of the neck it lies in front of the second part of the subclavian artery—the scalenus anterior separates the artery and nerve; in the thorax it lies lateral to the right innominate vein and superior vena cava. The *left phrenic nerve,* at the root of the neck, lies in front of the first part of the subclavian artery and is crossed by the thoracic duct; in the superior mediastinum it lies between the left common carotid and the left subclavian arteries where it crosses the left vagus from the lateral to the medial side; it then passes behind the left innominate vein and crosses the left side of the arch of the aorta. It is longer than the right nerve, due to its curving over the apex of the heart which projects to the left and also due to the diaphragm being on a lower level on the left side than on the right.

Besides supplying the diaphragm, the phrenic nerve also gives fine filaments to the pericardium and pleura. It communicates with the ansa hypoglossi, the cervical part of the sympathetic and the cœliac plexus of the sympathetic. One or two filaments of the right phrenic nerve join with the phrenic branches of the cœliac plexus to form the *diaphragmatic ganglion.*

The **communicating branches** are: (1) a grey ramus communicans from the superior cervical ganglion of the sympathetic trunk passes to each of the first four cervical nerves; (2) a communicating branch passes from the fourth to the fifth cervical nerve; (3) a twig from the loop between the first and second cervical nerve passes to the ganglion nodusum of the vagus; (4) a large portion of the first cervical nerve joins the hypoglossal and ultimately separates from the hypoglossal to form three branches viz., the descending branch (descendens hypoglossi), the nerve to the thyreohyoideus and the nerve to the geniohyoideus. It is believed that no portion of the hypoglossal nerve enters into the formation of the three branches just referred to.

## Deep Branches—Lateral Set

**Muscular branches.**—The sternocleidomastoideus is supplied from the second cervical nerve; the scalenus medius, trapezius, and levator scapulæ are supplied from the third and fourth cervical nerves.

The **communicating branches** are three and join the accessory nerve in three places: (1) a branch from the second cervical joins in the substance of the sternocleidomastoideus; (2) branches from the third and fourth cervical nerves to the trapezius join it in the posterior triangle ; (3) branches from the third and fourth cervical nerves join beneath the trapezius.

## The Brachial Plexus

**Composition.**—The **brachial plexus** (Figs. 278, 283) is formed by the anterior divisions of the fifth, sixth, seventh, and eighth cervical nerves and the greater part of the anterior division of the first thoracic nerve. Usually a branch from the fourth cervical nerve joins the fifth cervical and not infrequently a branch from the second thoracic communicates with the first thoracic nerve. These nerves constitute the *roots* of the plexus and lie between the scaleni anterior and medius. Three *trunks* are then formed by the union of these roots : thus the fifth and sixth cervical nerves unite to form a trunk called the *upper trunk ;* the seventh cervical remains alone forming the *middle trunk ;* while the eighth cervical and the branch from the first thoracic unite to form the *lower trunk.* The upper and middle trunks lie above the subclavian artery whilst the lower trunk lies behind it. Each of the three trunks formed in this way divides behind the clavicle into an *anterior* and a *posterior division.* These divisions lie on the lateral side of the first part of the axillary artery. The anterior divisions of the upper and middle trunks unite to form the *lateral cord.* The anterior division of the lower trunk remains alone forming the *medial cord* whilst the posterior divisions of all the three trunks unite to form the *posterior cord.* The lateral, medial and posterior cords occupy the corresponding sides of the second part of the axillary artery.

From the above description it will be seen that a typical brachial plexus may be divided into *four stages* viz., first stage—nerve roots ; second stage—nerve trunks ; third stage—divisions of nerve trunks ; fourth stage—nerve cords. The following table shows at a glance the formation of the brachial plexus :—

| | | | | |
|---|---|---|---|---|
| Roots | 5th and 6th C.Ns. =Upper trunk =Ant. dvn. | Lateral cord | and Post. dvn. | Posterior cord |
| | 7th C.N. =Middle trunk =Ant. dvn. | | and Post. dvn. | |
| | 8th C.N. and 1st Th.N. =Lower trunk =Ant. dvn. | Medial cord | and Post. dvn. | |

**Position and relations of the plexus.**—The brachial plexus lies successively (1) in the lower and anterior parts of the posterior triangle of the neck ; (2) behind the clavicle ; and (3) in the axilla. **In the neck** the nerves forming the plexus appear between the scalenus anterior and scalenus medius in series with the nerves forming the cervical plexus ; here the plexus is covered by the skin, platysma and fascia colli and is crossed by the supraclavicular nerves, the nerve to the subclavius, the external jugular vein, the transverse cervical artery and the inferior belly of the omohyoideus ;—the upper and middle trunks lie above while the lower trunk lies behind the third part of the subclavian artery.

**Behind the clavicle.**—When the plexus passes behind the clavicle, the subclavius, and transverse scapular vessels, it rests upon the scalenus medius. **In the axilla** the plexus is covered by the pectoralis major and minor and coracoclavicular fascia and is crossed by the cephalic vein and axillary artery; behind it are

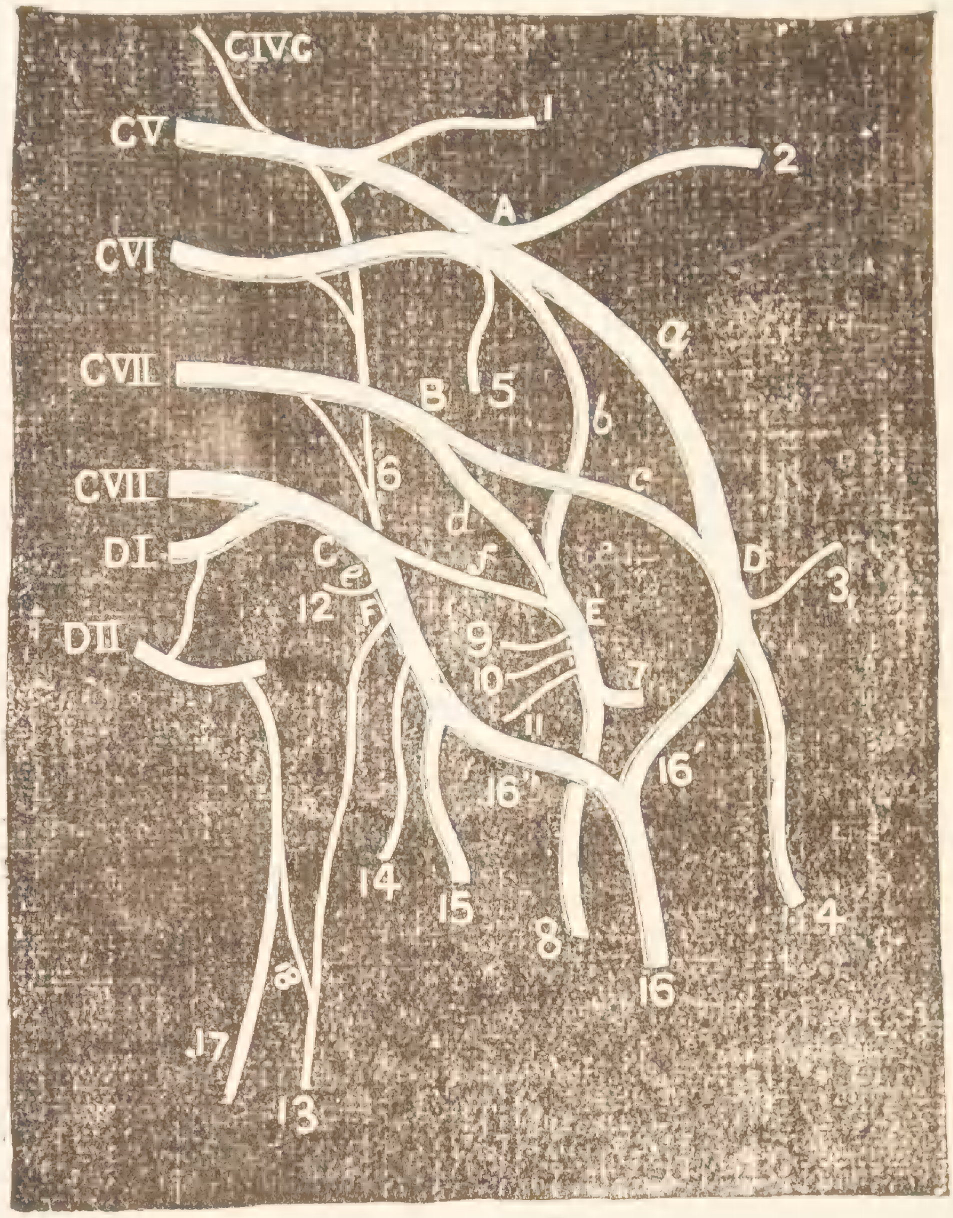


Fig. 283.—Diagram of the brachial plexus of nerves.

CIVC. Communicating branch from the fourth cervical nerve.

CV, CVI, CVII, CVIII, DI, DII. Anterior primary divisions of the fifth, sixth, seventh and eighth cervical nerves, and first and second thoracic nerves.

A. Upper trunk dividing into *a*, *b*, anterior and posterior divisions.
B. Middle trunk dividing into *c*, *d*, anterior and posterior divisions.
C. Lower trunk dividing into *e*, *f*, anterior and posterior divisions.
D. Lateral cord.
E. Posterior cord.
F. Medial cord.
1. Dorsal scapular nerve.
2. Suprascapular nerve.
3. Lateral anterior thoracic nerve.
4. Musculocutaneous nerve.
5. Nerve to subclavius.
6. Long thoracic nerve.
7. Axillary nerve.
8. Radial nerve.
9. 11. Upper and lower subscapular nerves.
10. Thoracodorsal nerve.
12. Medial anterior thoracic nerve.
13. Medial brachial cutaneous nerve.
14. Medial antibrachial cutaneous nerve.
15. Ulnar nerve.
16. Median nerve.
16′. Lateral head of median nerve.
16″. Medial head of median nerve.
17. Intercostobrachial nerve.
18. Communicating twig from the intercostobrachial nerve to the medial brachial cutaneous nerve.

the first digitation of the serratus anterior and the subscapularis. The cords of the brachial plexus and the first part of the axillary artery together with the vein are enclosed in the axillary sheath; here the medial cord lies behind the artery and the lateral and posterior cords on the lateral side of the artery. The cords are arranged around the second part of the axillary artery, the lateral cord lying on the lateral side, the medial cord on the medial side, and the posterior cord behind the artery.

The **communications** of the nerve roots of the plexus with the sympathetic trunk have been described (p. 586).

The **branches of the brachial plexus** can be divided into two sets, viz., those which arise *above* the clavicle are called *supraclavicular branches* and those *below* the bone are named the *infraclavicular branches.*

### The Supraclavicular Branches

| | |
|---|---|
| To phrenic | C. 5 |
| To scaleni and longus colli | C. 5, 6, 7, 8 |
| Dorsal scapular | C. 5 |
| To subclavius | C. 5, 6 |
| Suprascapular | C. 5, 6 |
| Long thoracic | C. 5, 6, 7 |

The **communicating branch to the phrenic nerve** is derived from the fifth cervical nerve and joins it upon the scalenus anterior muscle.

The **muscular branches** to the scaleni and longus colli are derived from the lower four cervical nerves soon after their exit from the intervertebral foramina.

The **dorsal scapular nerve** (nerve to rhomboidei) arises from the fifth cervical nerve, pierces the scalenus medius and passes beneath the levator scapulæ accompanied by the descending branch of the transverse cervical artery and supplies the rhomboidei. It occasionally supplies a twig to the levator scapulæ.

The **nerve to the subclavius** is a slender twig which arises from the upper trunk of the plexus formed by the union of the fifth and sixth cervical nerves and descends in front of the third part of the subclavian artery to supply the subclavius.

The **suprascapular nerve** arises from the upper trunk of the brachial plexus, passes downwards and lateralwards beneath the omohyoideus and the trapezius and enters the supraspinous fossa by passing through the suprascapular notch beneath the superior transverse ligament of the scapula. Here it supplies the supraspinatus and gives one articular twig to the shoulder joint. It then passes through the great scapular notch, reaches the infraspinous fossa and supplies the infraspinatus; here it gives the second articular twig to the shoulder joint.

The **long thoracic nerve** (posterior thoracic or external respiratory nerve of Bell) arises by three roots from the fifth, sixth and seventh cervical nerves. The roots from the fifth and sixth cervical nerves pierce the scalenus medius and that from the seventh cervical nerve passes in front of the muscle. The nerve runs downwards behind the brachial plexus and the axillary vessels and lies upon the outer surface of the serratus anterior supplying twigs to each of its digitations.

### The Infraclavicular Branches

*From the Lateral Cord*

| | |
|---|---|
| Lateral anterior thoracic | C. 5, 6, 7 |
| Musculocutaneous | C. 5, 6, 7 |
| Lateral head of median | C. 6, 7 |

*From the Medial Cord*

| | |
|---|---|
| Medial head of median | C. 8, T. 1 |
| Medial anterior thoracic | |
| Medial brachial cutaneous | |
| Medial antibrachial cutaneous | |
| Ulnar | |

*From the Posterior Cord*

| | |
|---|---|
| Upper and lower subscapular | C. 5, 6 |
| Axillary | |
| Thoracodorsal | C. 5, 6, 7 |
| Radial | C. 5, 6, 7, 8, T. 1 |

The **lateral anterior thoracic nerve** (external anterior thoracic nerve) arises from the lateral cord of the brachial plexus and derives its fibres from the fifth, sixth and seventh cervical nerves. It passes forwards and, crossing the axillary artery and vein, pierces the coracoclavicular fascia. It then enters the deep surface of the pectoralis major to supply it. A filament from it usually joins the medial anterior thoracic nerve forming a loop in front of the axillary artery.

The **musculocutaneous nerve** (Fig. 225) arises from the lateral cord of the brachial plexus and derives its fibres from the fifth, sixth and seventh cervical nerves. It passes obliquely downwards and lateralwards, supplies a branch to the coracobrachialis and then pierces the muscle. Continuing its course downwards and lateralwards it passes between the biceps brachii in front and the brachialis behind, supplies filaments to both the muscles and reaches the lateral border of the tendon of the biceps brachii in front of the elbow. There it perforates the deep fascia and is continued down into the forearm as the lateral antibrachial cutaneous nerve. The nerve to the coracobrachialis has an independent origin from the sixth and seventh cervical nerves and is incorporated with the trunk of the musculocutaneous nerve but it often springs as an inedpendent branch of the lateral cord of the brachial plexus. It leaves the musculocutaneous nerve before that nerve pierces the muscle. The branches to the biceps brachii and brachialis are given off after the trunk has pierced the coracobrachialis; the branch to the brachialis supplies a twig to the elbow joint. In addition the nerve supplies a medullary branch to the humerus.

The *lateral antibrachial cutaneous nerve* is the cutaneous part of the musculocutaneous nerve. It pierces the deep fascia in front of the elbow, passes downwards behind the cephalic vein along the radial side of the front of the forearm to the wrist. Its terminal part can be traced to the ball of the thumb; it communicates with the palmar cutaneous branch of the median nerve and with the superficial branch of the radial nerve. Near the wrist it lies in front of the radial artery and some twigs pass with the artery, pierce the deep fascia and supply the dorsal aspect of the carpus. In its course along the forearm it gives off branches which pass dorsally round the radial border of the forearm and communicates with the dorsal antibrachial cutaneous nerve.

The **median nerve** (Fig. 225) derives its fibres from the sixth, seventh and eighth cervical and first thoracic nerves. It arises by two heads, viz., a lateral head derived from the lateral cord and a medial head from the medial cord of the brachial plexus. The two heads unite either in front of or on the lateral side of the third portion of the axillary artery. The nerve then descends on the lateral side of the brachial artery, crosses that vessel at about the middle of the arm and descends along its medial side to the bend of the elbow lying in front of the brachialis and covered by the lacertus fibrosus. It then enters the forearm between the two heads of the pronator teres and is separated from the ulnar artery by the ulnar head of that muscle. Crossing in front of the ulnar artery it runs in the forearm vertically downwards under cover of the flexor digitorum sublimis and in front of the flexor digitorum profundus. About two inches above the wrist it becomes superficial and lies under cover of the skin and fascia and situated between the tendons of the flexor digitorum sublimis medially and the tendon of the flexor carpi radialis laterally and behind the tendon of the palmaris longus. It then passes behind the transverse carpal ligament to the palm of the hand. The median artery which is derived from the volar interosseous artery accompanies the median nerve in the forearm.

**Branches.**—The median nerve usually gives off no branches in the arm. In the forearm its branches are: (1) *Muscular branches* to the pronator teres, the flexor carpi radialis, the palmaris longus, and the flexor digitorum sublimis. (2) The *palmar cutaneous branch* pierces the deep fascia above the transverse carpal ligament. It descends over the ligament and divides into two branches, a lateral and a medial. The lateral branch supplies the skin over the thenar eminence and communicates with the terminal part of the lateral antibrachial cutaneous nerve. The medial branch supplies the skin of the palm and communicates with the palmar cutaneous branch of the ulnar nerve. (3) The *volar interosseous nerve* (anterior interosseous nerve) passes along the front of the interosseous membrane in company with the volar interosseous artery and supplies the flexor pollicis longus and the lateral half of the flexor digitorum profundus. It then passes behind the pronator quadratus, supplies twigs to that muscle and terminates in the wrist joint.

In the palm of the hand the median nerve lies under cover of the palmar aponeurosis and superficial volar arch. At the distal border of the transverse carpal ligament it becomes enlarged and flattened and divides into two portions, a lateral and a medial. The *lateral portion* gives off (1) a *muscular branch* which supplies the abductor pollicis brevis, opponens pollicis, and the superficial head of the flexor pollicis brevis; and (2) three *proper volar digital branches*, two of which are distributed to the sides of the thumb and the third to the radial side of the index finger after supplying a twig to the first lumbrical muscle. The *medial portion* gives off (1) two *common volar digital branches*, of which the lateral one supplies a twig to the second lumbrical muscle and divides at the cleft between the index and middle fingers into two proper volar digital branches which supply the contiguous sides of those fingers. The medial one sends a communicating twig to the ulnar nerve and sometimes supplies a filament to the third lumbrical muscle; it divides opposite the cleft between the middle and ring fingers into two proper volar digital branches which supply the contiguous sides of those fingers. Each of these proper volar digital nerves also gives off one or two dorsal twigs to supply the skin on the dorsal aspects of the terminal phalanges of the corresponding digits; each divides ultimately into two twigs—one ramifies around and beneath the nail and the other supplies the pulp of the finger.

It will be seen that the median nerve supplies (1) the skin of three and a half digits, viz., the thumb, the index, the middle and the radial half of the ring finger; and (2) five muscles of the hand, viz., the opponens pollicis, the abductor pollicis brevis, the superficial head of the flexor pollicis brevis and the two lateral lumbricales. The ulnar nerve supplies the remaining digits and the remaining muscles of the hand.

The **medial anterior thoracic nerve** (internal anterior thoracic nerve) arises from the medial cord and derives its fibres from the eighth cervical and first thoracic nerves. Passing behind the first part of the axillary artery it proceeds forwards between that artery and its companion vein and is joined in front of the artery by a filament from the lateral anterior thoracic nerve. It then passes to the deep surface of the pectoralis minor to be distributed to that muscle; some filaments pierce the muscle and enter the deep surface of the pectoralis major to supply it.

The **medial brachial cutaneous nerve** (lesser internal cutaneous nerve) arises from the medial cord and derives its fibres from the eighth cervical and first thoracic nerves. It is the smallest branch of the brachial plexus. It runs through the axilla and descending in front of or behind the axillary vein lies along the medial side of that vein and sends a communicating twig to the intercostobrachial nerve. Continuing downwards along the medial side of the brachial artery, it pierces the deep fascia on the medial aspect of the arm at about its middle and supplies the skin on the medial and back part of the lower third of the arm.

The **medial antibrachial cutaneous nerve** (internal cutaneous nerve) (Figs. 247, 284) arises from the medial cord of the brachial plexus and derives its fibres from the eighth cervical and first thoracic nerves. It descends along the medial side of the axillary and brachial arteries, pierces the deep fascia usually with the basilic vein on the medial aspect of the arm at about its middle and divides into two terminal branches, volar and ulnar. Before it perforates the deep fascia it gives off a cutaneous branch which supplies the skin over the biceps brachii as low down as the elbow. The *volar branch* passes beneath the median cubital vein and then descends along the volar aspect of the medial side of the forearm supplying the skin as low down as the wrist. The *ulnar branch* passes in front of the medial epicondyle, then curves

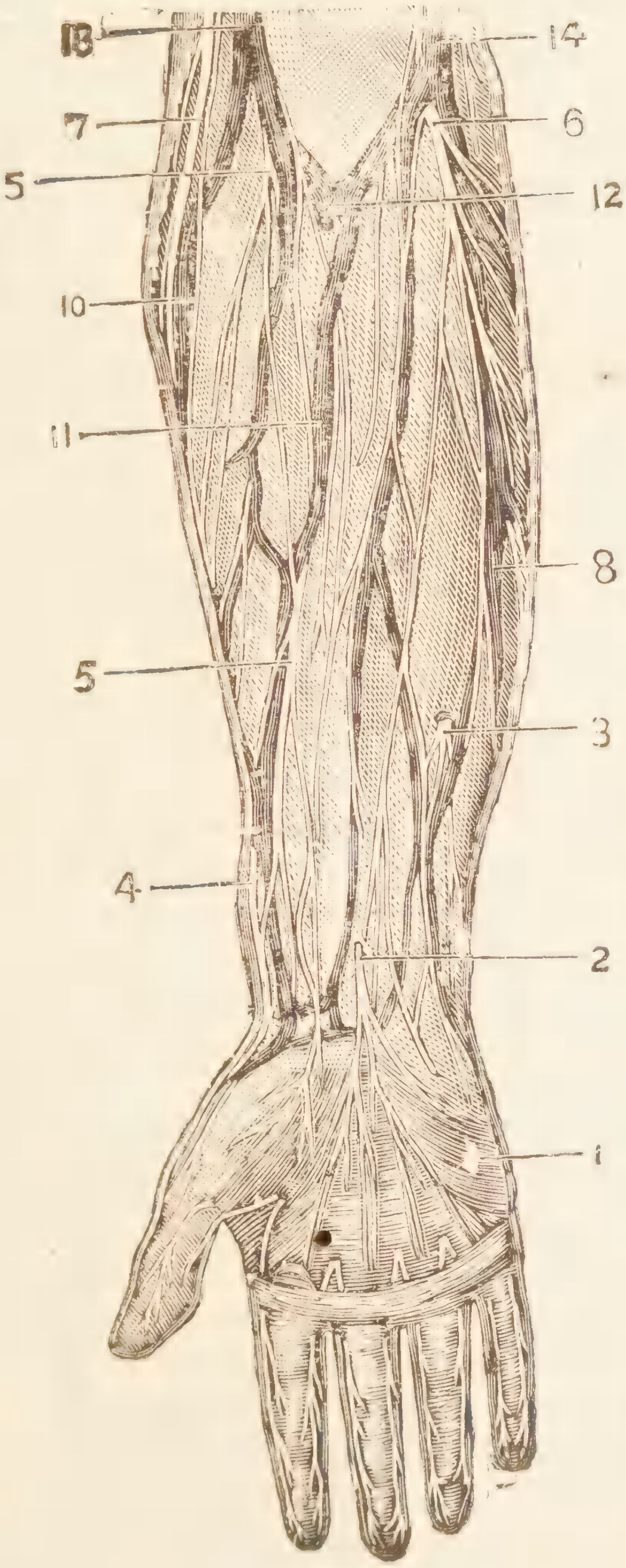


Fig. 284.—Cutaneous dissection of the front of the forearm and hand.

1. Palmaris brevis.
2. Palmar cutaneous branch of median nerve.
3. Palmar cutaneous branch of ulnar nerve.
4. Lateral branch of superficial branch of radial nerve.
5. Musculocutaneous nerve.
6. Medial antibrachial cutaneous nerve.
7. Dorsal antibrachial cutaneous branch of radial nerve.
8. Basilic vein.
10. Cephalic vein.
11. Median antibrachial vein.
12. A communicating vein joining the bifurcation of the median antibrachial vein.
13. Cephalic vein.
14. Basilic vein.

round to the dorsum of the forearm and proceeds downwards on its medial side as far as the wrist.

The **ulnar nerve** (Fig. 225) arises from the medial cord of the brachial plexus and derives its fibres from the eighth cervical and first thoracic nerves. In 50 per cent. of cases it has also a root from the lateral cord of the plexus or from the lateral head of the median nerve. It runs downwards along the medial side of the axillary and brachial arteries to the middle of the arm. Here, it parts company with the brachial artery and descends with the superior ulnar collateral artery, with which it passes through the medial intermuscular septum. It then descends along the medial head of the triceps brachii to the interval between the medial epicondyle of the humerus and the olecranon. It next lies in the sulcus nervi ulnaris on the back part of the medial epicondyle of the humerus and passes into the forearm between the two heads of origin of the flexor carpi ulnaris. Thereafter it descends along the volar aspect of the ulnar side of the forearm being covered by the flexor carpi ulnaris and placed upon the flexor digitorum profundus. In the distal half of the forearm it lies on the lateral side of the flexor carpi ulnaris and is superficial being covered only by the skin and fasciæ. In the upper third of the forearm the nerve remains at some distance from the ulnar artery while in the lower two thirds it lies to the medial side of the artery. It then passes over the transverse carpal ligament close to the pisiform bone and reaches the palm of the hand. Here, after supplying a twig to the palmaris brevis it subdivides into its terminal branches, called the superficial and deep.

**Branches.**—The ulnar nerve gives off no branch in the arm. In the forearm the branches are :—(1) The *articular branches* arise from the nerve as it lies between the medial epicondyle and the olecranon and enter the elbow joint. (2) The *muscular branches* supply the flexor carpi ulnaris and the medial half of the flexor digitorum profundus. (3) The *palmar cutaneous branch* springs about the middle of the forearm, descends in front of the ulnar artery and perforates the deep fascia about an inch above the wrist ; it supplies the skin on the medial aspect of the palm. (4) The *dorsal branch* issues about two inches above the wrist and passes to the dorsum of the forearm by winding round its ulnar border under cover of the flexor carpi ulnaris. Piercing the deep fascia it descends along the ulnar side of the dorsum of the wrist and hand. It then divides into two dorsal digital branches and a communicating branch. Of the two *dorsal digital branches*, one supplies the medial margin of the dorsum of the hand and the little finger ; the other is distributed to the contiguous sides of the little and ring fingers on the dorsal aspect. But they do not supply the dorsal aspects of the terminal phalanges, which receive twigs from the proper digital branches of the ulnar nerve on the volar aspect. The *communicating branch* joins the twig from the superficial branch of the radial nerve which supplies the contiguous sides of the ring and middle fingers on their dorsal aspects.

The *superficial branch* is purely cutaneous and subdivides into two branches, a proper volar digital nerve and a common volar digital nerve. The former supplies the medial side of the little finger; the latter sends a communicating filament to the median nerve and then divides into two proper volar digital nerves which supply the contiguous sides of the little and ring fingers. At the terminal phalanx the digital nerve divides into two branches of which one supplies the pulp and the other ramifies beneath the nail. The *deep branch* accompanies the deep branch of the ulnar artery, passes between the abductor digiti quinti and the flexor digiti quinti brevis and then through the fibres of opponens digiti quinti and supplies these three short muscles of the little finger. It then proceeds lateralwards beneath the flexor tendons and lies along the course of the deep volar arch. Reaching the lateral side of the palm it divides into terminal filaments which supply the first dorsal interosseous muscle, the adductor pollicis, and the deep portion of the flexor pollicis brevis. During its course across the palm it supplies branches to all the other interossei and the two medial lumbricales. It also supplies twigs to the wrist joint.

The **subscapular nerves** are two in number, upper and lower. They arise from the posterior cord and derive their fibres from the fifth and sixth cervical nerves. The *upper subscapular nerve,* the smaller of the two, enters the upper part of the subscapularis. The *lower subscapular nerve* supplies the lower part of the subscapularis and the teres major.

The **thoracodorsal nerve** (middle or long subscapular nerve) arises from the posterior cord and derives its fibres from the fifth, sixth and seventh cervical nerves. It passes downwards in company with the subscapular artery along the posterior wall of the axilla to supply the latissimus dorsi.

The **axillary nerve** (circumflex nerve) (Fig. 225) arises from the posterior cord of the brachial plexus and derives its fibres from the fifth and sixth cervical nerves. At first it lies behind the axillary artery and leaves the axilla at the lower border of the subscapularis by turning backwards through the quadrilateral space (p. 225) in company with the posterior humeral circumflex artery. In the quadrilateral space it divides into two branches, an anterior and a posterior, and before the division takes place it supplies a twig to the shoulder joint. The *anterior branch* passes in company with the posterior humeral circumflex artery and winding round the surgical neck of the humerus under cover of the deltoideus breaks up into several filaments which enter the deep surface of the anterior part of the deltoideus; some filaments pierce the muscle and ramify in the skin covering its anterior part. The *posterior branch* gives off a twig to the teres minor which presents an elongated swelling (pseudoganglion) on it. After supplying a few twigs to the posterior part of the deltoideus the posterior branch pierces the deep fascia and is continued as the *lateral brachial cutaneous nerve* which winding round the posterior border of the deltoideus is distributed to the skin covering the posterior part of this muscle and the back of the arm.

It may be noted that *Hilton's law*—"a nerve supplying a given joint supplies the muscles moving that joint and the skin covering their insertions"—is applicable in the case of the axillary nerve which supplies the shoulder joint, the deltoideus, and the skin covering the insertion of this muscle.

The **radial nerve** (musculospiral nerve) (Fig. 225) is the largest branch of the brachial plexus and may be regarded as the direct continuation downwards of the posterior cord. It derives its fibres from the last four cervical nerves and sometimes also from the first thoracic nerve. In the axilla it descends behind the third part of the axillary artery and in front of the subscapularis, teres major and latissimus dorsi. In the upper third of the arm it lies behind the brachial artery and upon the long head of the triceps brachii. In the middle third of the arm, it proceeds backwards, passes with the arteria profunda brachii along the radial sulcus of the humerus between the lateral and medial heads of the triceps brachii and reaches the lateral side of the limb. In the lower third of the arm, it pierces the lateral intermuscular septum to gain the front aspect of the arm. It then passes downwards in the interval between the brachialis medially and the brachioradialis and extensor carpi radialis longus laterally to the front of the lateral epicondyle of the humerus where it divides under cover of the brachioradialis into two terminal branches, the superficial and deep.

**Branches.**—The radial nerve gives off muscular, cutaneous and terminal branches. At the back aspect of the arm the *muscular branches* supply the three heads of the triceps brachii and the anconæus. The nerve to the medial head of the triceps brachii is a long, slender branch which, on account of its lying close to the ulnar nerve, is called the *ulnar collateral nerve.* The nerve to the aconæus is a slender branch which descends through the substance of the medial head of the triceps brachii and ends in the anconæus. It is accompanied by the middle collateral branch of the arteria profunda brachii. At the front aspect of the arm the muscular branches supply the lateral part of the brachialis, the brachioradialis and extensor carpi radialis longus. The *cutaneous branches* are two in number, viz., the posterior brachial cutaneous and dorsal antibrachial cutaneous.

The *posterior brachial cutaneous nerve* (internal cutaneous branch of the musculospiral nerve) arises in the axilla, passes to the back part of the arm and supplies the skin on its dorsal aspect. It can be traced as far as the olecranon. It communicates with the intercostobrachial nerve.

The *dorsal antibrachial cutaneous nerve* (external cutaneous branch of the musculospiral nerve) consists of two branches, an upper and a lower. They arise from the radial nerve before it pierces the lateral intermuscular septum. Both become cutaneous by piercing the deep fascia close together on the lateral side of the arm at about its middle. The *upper branch* is the smaller and runs close to the cephalic vein ; it supplies the skin of the lower third of the arm on its lateral aspect. The *lower branch* descends along the lateral side of the arm and the dorsal aspect of the forearm to the wrist supplying the skin and communicating with the dorsal branches of the lateral antibrachial cutaneous nerve.

The *superficial branch of the radial nerve* (radial nerve) is entirely cutaneous in its distribution. It runs downwards over the supinator covered by the brachioradialis in the upper two thirds of the forearm. In the middle third of the forearm, it is accompanied by the radial artery which lies on its medial side. It then quits the artery and winding round the lateral side of the forearm pierces the deep fascia and divides into a lateral and a medial branch. The *lateral branch* is the smaller and is distributed to the skin of the radial border of the hand and the thumb and communicates with the volar branch of the lateral antibrachial cutaneous nerve. The *medial branch* divides into four dorsal digital branches : the first supplies the ulnar side of the thumb ; the second, the radial side of the index finger ; the third, the contiguous sides of the index and middle fingers ; and the fourth, the adjoining sides of the middle and ring fingers. These dorsal digital nerves do not supply the dorsal aspects of the terminal phalanges which receive twigs from the proper volar digital branches of the median nerve on the volar aspect. The fourth digital branch is joined by the communicating filament from the dorsal branch of the ulnar nerve.

The *deep branch of the radial nerve* (posterior interosseous nerve) is chiefly muscular but also articular in its distribution. Arising under cover of the brachioradialis it reaches the dorsum of the forearm, after winding round the lateral side of the radius by passing between the superficial and deep planes of the supinator. It then descends between the superficial and deep groups of muscles to the upper margin of the extensor pollicis longus. Being much reduced in size by giving off all its muscular branches it passes in front of the extensor pollicis longus and descends on the dorsal aspect of the interosseous membrane as the **dorsal interosseous nerve** to the dorsum of the carpus lying in the same compartment of the dorsal carpal ligament with the extensor digitorum communis and extensor indicis proprius. Here it terminates in a gangliform enlargement from which twigs are given off to the joints of the carpus. Before the deep branch of the radial nerve gains the dorsum of the forearm it supplies branches to the extensor carpi radialis and the supinator. On the dorsum of the forearm it supplies the extensor digitorum communis, exensor digiti quinti proprius, extensor carpi ulnaris, abductor pollicis longus, the extensores pollicis longus and brevis and the extensor indicis proprius.

## The Anterior Divisions of the Thoracic Nerves

The anterior divisions of the **thoracic nerves** are twelve in number on each side; each nerve issues below the corresponding vertebra and rib. They do not form plexuses but remain distinct from each other. Eleven of them lie between the ribs and are thus called **intercostal nerves** while the twelfth lies below the last rib. Each nerve communicates with the sympathetic ganglion by two branches. A grey ramus communicans which passes to each nerve from the adjoining ganglion; and a white ramus communicans which passes to the adjoining ganglion. The first, second, and twelfth thoracic nerves present peculiarities in their course and distribution and thus require separate description. The remainder are divided into two groups: the upper group consists of four nerves, the third to the sixth inclusive, which are called *thoracic intercostal nerves* and are distributed entirely to the thoracic wall; the lower group consists of five nerves, the seventh to the eleventh inclusive, which are called *thoracico-abdominal intercostal nerves* and are distributed to the thoracic as well as the abdominal wall.

The anterior division of the **first thoracic nerve** emerges below the neck of the first rib and divides in the first inercostal space into a larger and a smaller branch. The *larger branch* passes upwards and lateralwards over the neck of the first rib on the lateral side of the arteria intercostalis suprema to the root of the neck behind the subclavian artery and the pleura. It then proceeds upon the scalenus medius and joins the brachial plexus. The *smaller branch* is the *first intercostal nerve*; it runs forwards in the first intercostal space, supplies the intercostal muscles and ends as the *first anterior cutaneous nerve of the thorax*; it gives off no lateral cutaneous branch but occasionally sends a small branch which communicates with the medial brachial cutaneous nerve and the intercostobrachial nerve in the axilla.

The anterior division of the **second thoracic nerve** sends a communicating filament which passes upwards along the neck of the second rib to join the larger branch of the first thoracic nerve; it then pierces the posterior intercostal membrane and runs forwards in the second intercostal space lying in the costal groove between the external and internal intercostal muscles. Reaching the level of the midaxillary line it gives off a large lateral cutaneous branch which is called the *intercostobrachial nerve*; this nerve, like the other lateral cutaneous branches, does not divide into an anterior and a posterior branch. The undivided nerve pierces the intercostal and serratus anterior muscles and, crossing the axilla, passes to the medial side of the arm. It pierces the deep fascia near the posterior fold of the axilla and descends up to the region of the medial epicondyle of the humerus. It supplies the skin over the axilla and over the posterior and medial aspects of the arm. In the axilla it communicates by a filament with the medial brachial cutaneous nerve and in the arm with the posterior brachial cutaneous branch of the radial nerve. The size of the intercostobrachial nerve varies in inverse proportion to that of the medial brachial cutaneous nerve; when the latter nerve is absent the intercostobrachial takes its place.

Anterior divisions of the **third, fourth, fifth, and sixth thoracic nerves.**—Each of these nerves (Fig. 285) lies at first between the parietal pleura and posterior intercostal membrane. Near the angle of the rib it pierces the posterior intercostal membrane and passes forwards in the costal groove between the external and internal intercostal muscles. It continues its forward course in this position in company with the intercostal artery and vein—the vein lies above, the artery in the middle, and the nerve below.

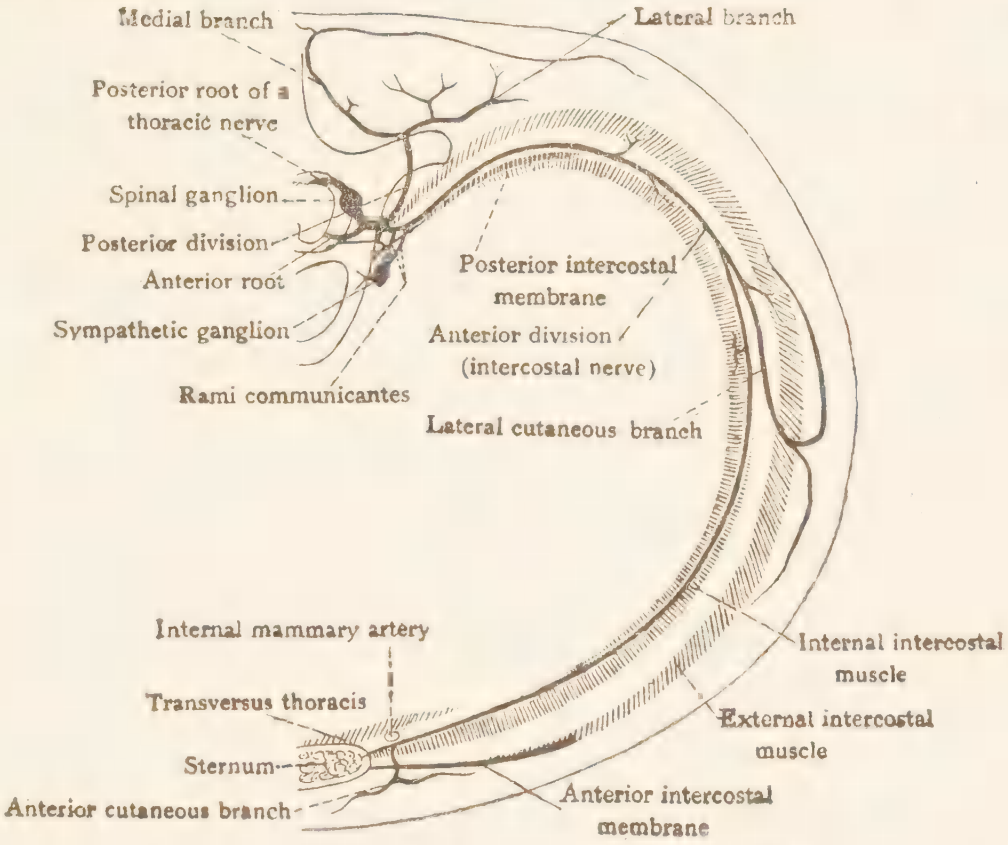

Medial branch
Lateral branch
Posterior root of a thoracic nerve
Spinal ganglion
Posterior division
Anterior root
Sympathetic ganglion
Rami communicantes
Posterior intercostal membrane
Anterior division (intercostal nerve)
Lateral cutaneous branch
Internal mammary artery
Transversus thoracis
Sternum
Anterior cutaneous branch
Internal intercostal muscle
External intercostal muscle
Anterior intercostal membrane

Fig. 285.—Diagram of the course and distribution of a typical thoracic nerve.

About midway between the vertebral column and sternum the nerve gives off the lateral cutaneous branch. It now leaves the intermuscular space, enters the internal intercostal muscle and pursues its forward course in the substance of this muscle. At the junction of the rib with its cartilage, the nerve emerges from that muscle and comes to lie upon its deep surface, between the muscle and the pleura. Further forwards it crosses in front of the internal mammary artery and the transversus thoracis and at the side of the sternum it perforates the internal intercostal muscle, the anterior intercostal membrane, the pectoralis major and the deep fascia to become the *anterior cutaneous nerve of the thorax* which supplies the skin of the front of the chest corresponding to the anterior part of the intercostal space.

**Branches.**—Each of these nerves gives off: (1) *muscular branches* which supply the intercostales, transversus thoracis, levatores costarum, subcostalis, and serratus posterior superior. (2) The *lateral cutaneous branch* pierces the external intercostal muscle, passes between the digitations of the serratus anterior and divides into an anterior and a posterior offset : the former passes forwards over the pectoralis major ; the latter proceeds towards the scapula. The posterior offset of the lateral cutaneous branch of the third thoracic nerve passes to the arm, supplies the skin on the medial side of the upper arm and often joins the intercostobrachial nerve.

Anterior divisions of the **seventh, eighth, ninth, tenth,** and **eleventh thoracic nerves.**—Each of these nerves has the same course and gives off the same branches in the thoracic wall like the preceding nerves, viz. third to the sixth inclusive. In addition each nerve has a further course in the abdominal wall. Reaching the anterior end of the intercostal space the nerve passes between the interdigitating slips of the diaphragm and the transversus abdominis and proceeds forwards in the abdominal wall between the transversus abdominis and the obliquus internus. It then enters the sheath of the rectus abdominis and piercing the muscle, the anterior layer of its sheath, and the deep fascia, enters the superficial fascia to be distributed to the skin in front of it assuming the name of the *anterior cutaneous nerve of the abdomen.* **Branches.**—Each of these nerves gives off : (1) *muscular branches* which supply the intercostal muscles, transversus abdominis, obliquus externus and internus, and rectus abdominis ; (2) *lateral cutaneous branches* which arise about the middle of their course, pierce the external intercostal muscles and the obliquus externus abdominis in the same line as the lateral cutaneous branches of the upper group of thoracic nerves and divide into anterior and posterior branches—the former run downwards and forwards to supply the skin of the front of the abdomen ; the latter run backwards to supply the skin over the latissimus dorsi.

The anterior division of the **twelfth thoracic nerve** appears immediately below the last rib and gives off a communicating branch to the first lumbar nerve. It then passes along the lower border of the last rib in company with the subcostal artery and proceeds beneath the lateral lumbocostal arch. Thereafter it runs in front of the quadratus lumborum and behind the kidney, pierces the posterior aponeurosis of the transversus abdominis and pursues its forward course between that muscle and the internal oblique. The rest of its course and distribution is similar to that of a lower intercostal nerve. *Branches.*—It gives off in addition a muscular branch to the pyramidalis. Its lateral cutaneous branch does not divide into an anterior and a posterior branch ; it pierces both oblique muscles, and becomes superficial above the iliac crest about 2 inches behind the anterior superior iliac spine and supplies the skin of the front part of the gluteal region as far down as the greater trochanter of the femur.

### The Anterior Divisions of the Lumbar, Sacral and Coccygeal Nerves

The anterior divisions of the five **lumbar nerves,** five **sacral nerves** and one **coccygeal nerve** unite to form the **lumbosacral** plexus. Partly for convenience of description and partly on account of the differences in position and course of some of the nerves arising from it, this plexus is subdivided into four plexuses—the lumbar, sacral, pudendal, and coccygeal. As the four plexuses overlap, there is no definite line of demarcation. The anterior divisions of the lumbar, sacral and coccygeal nerves each receive a grey ramus communicans from the lumbar and sacral ganglia of the sympathetic: one nerve may receive rami from two ganglia, or one ganglion may send rami to two nerves. These rami are long and slender, in the case of lumbar nerves, and they run in company with the lumbar arteries laterally over the bodies of the vertebræ and beneath the psoas major. The first, second, and sometimes the third and fourth lumbar nerves are connected with the sympathetic trunk by white rami communicantes. The fifth lumbar and first sacral do not give white rami. The second, third and fourth sacral nerves give white rami which do not join the sympathetic trunk but enter the pelvic plexus of the sympathetic.

## The Lumbar Plexus

**Constitution and position.**—The lumbar plexus (Fig. 286) is formed by the anterior divisions of the first three lumbar nerves and a part of that of the fourth lumbar; a branch from the twelfth thoracic nerve usually joins the first lumbar. The remaining part of the anterior division of the fourth lumbar nerve unites with the anterior division of the fifth lumbar to form the *lumbosacral trunk* which passes downwards behind the

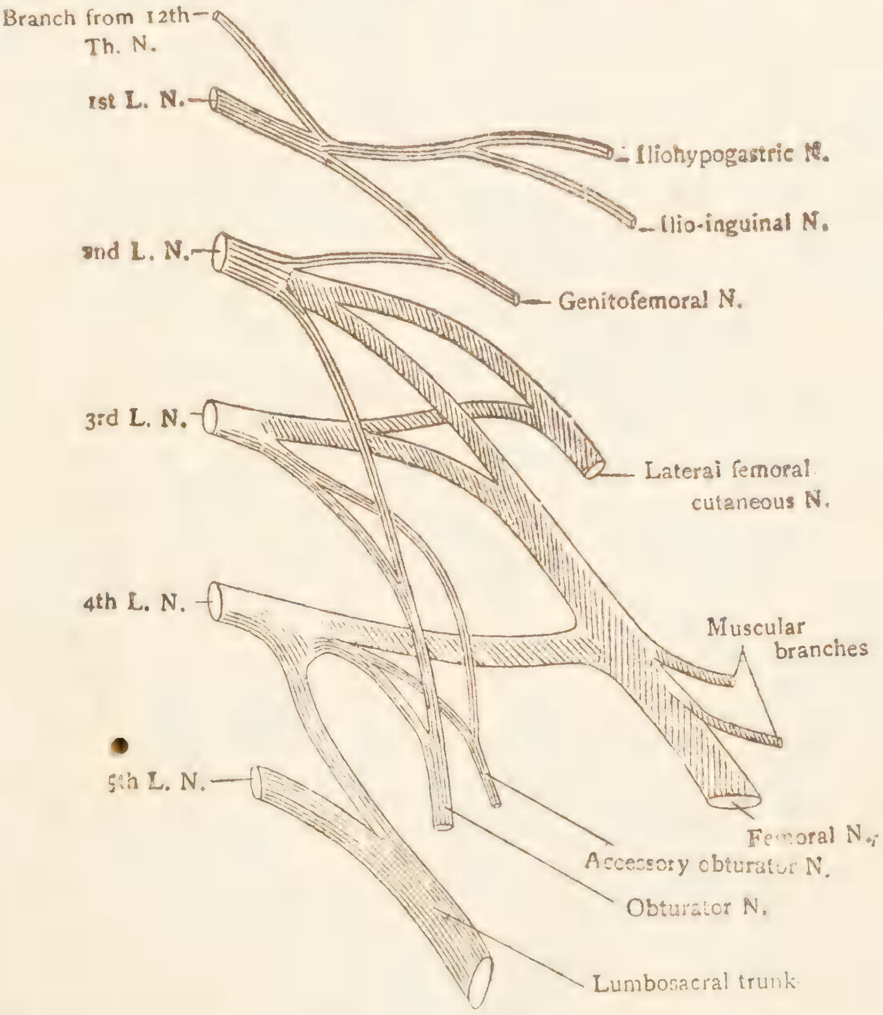


Fig 286.—Diagram of the lumbar plexus.

common iliac artery to join the sacral plexus. The fourth lumbar nerve is called the *nervus furcalis* on account of the fact that it divides to join both the lumbar and sacral plexuses. The lumbar plexus is contained in the substance of the psoas major near the posterior surface of the muscle and is placed in front of the transverse processes of the lumbar vertebræ.

The usual arrangement of the lumbar plexus is as follows: the first lumbar nerve is joined by a branch from the last thoracic; it divides into three branches—the iliohypogastric, the ilioinguinal, and the upper root of the genitofemoral. Each of the second, third and fourth lumbar nerves divides into a ventral and a dorsal division and gives off other branches. The obturator nerve is formed by the union of the three ventral divisions. The femoral nerve is formed by the union of the three dorsal divisions. The genitofemoral is formed by the union of an upper and a lower root, the former being contributed by the first lumbar nerve and the latter by the ventral division of the second lumbar nerve. The lateral femoral cutaneous nerve is formed by the union of two roots derived from the dorsal divisions of the second and third lumbar nerves. The accessory obturator nerve when present is formed by two roots derived from the ventral divisions of the third and fourth lumbar nerves.

### The Branches of the Lumbar Plexus

| | |
|---|---|
| To quadratus lumborum | L. 1, 2 |
| To psoas major | L. 2, 3 |
| To psoas minor | L. 1 |
| Iliohypogastric | L. 1 |
| Ilioinguinal | L. 1 |
| Genitofemoral | L. 1, 2 |
| Lateral femoral cutaneous | L. 2, 3 |
| Obturator | L. 2, 3, 4 |
| Accessory obturator | L. 3, 4 |
| Femoral | L. 2, 3, 4 |

The **branches** given off from the lumbar plexus are:—

(1) **Muscular branches.**—The psoas minor is supplied from the first lumbar, the psoas major from the second and third lumbar, the quadratus lumborum from the first and second lumbar nerves.

(2) The **iliohypogastric nerve** arises from the first lumbar nerve and appears at the lateral border of the psoas major at its upper part. It then passes obliquely downwards and lateralwards in front of the quadratus lumborum and behind the kidney towards the iliac crest. Here it pierces the posterior part of the transversus abdominis a little above the crest of the ilium. It then passes forwards between the internal oblique and the transversus and divides into a lateral cutaneous branch and an anterior cutaneous branch. The *lateral cutaneous branch* pierces the internal and external oblique muscles and crosses the iliac crest to be distributed in the gluteal region. The *anterior cutaneous branch* passes between the internal oblique and the trans-

versus, and after supplying branches to them pierces the former muscle in front of the anterior superior iliac spine. It then pierces the aponeurosis of the external oblique about an inch above the subcutaneous inguinal ring and supplies the skin of the anterior abdominal wall above the os pubis.

(3) The **ilioinguinal nerve** arises from the first lumbar nerve. Sometimes the iliohypogastric and ilioinguinal nerves are represented in the first part of their course by one trunk. The nerve appears at the lateral border of the psoas major just below the iliohypogastric. It crosses in front of the quadratus lumborum obliquely and perforates the transversus abdominis a little above the front part of the iliac crest. It then passes between the internal oblique and the transversus abdominis, supplying both the muscles. It next pierces the internal oblique and proceeding forwards beneath the aponeurosis of the obliquus externus abdominis above the inguinal ligament it becomes cutaneous by passing through the subcutaneous inguinal ring. It is distributed to the skin over the symphysis pubis, to the skin over the upper part of the scrotum and root and dorsum of the penis in the male and to the skin over the mons pubis, labia majus in the female, and to the skin of the upper and medial part of the thigh.

(4) The **genitofemoral nerve** (genitocrural nerve) arises by two roots, one from the first lumbar and the other from the ventral division of the second lumbar. It passes through the psoas major and appears at its medial border. It then descends on the surface of the muscle and divides into two branches, the external spermatic and lumboinguinal nerves. The *external spermatic nerve* (genital branch) crosses the external iliac artery to reach the abdominal inguinal ring, through which it passes to supply the cremaster muscle. In the female it passes with the round ligament of the uterus and ends in the labium majus. The *lumboinguinal nerve* (crural branch) descends lateral to the external iliac artery and passes behind the inguinal ligament to the thigh on the lateral side of the femoral artery. It pierces the fascia lata about an inch below the middle of the inguinal ligament on the lateral side of the femoral artery. It supplies the skin over the femoral triangle and communicates with the intermediate femoral cutaneous nerve.

(5) The **lateral femoral cutaneous nerve** (external cutaneous nerve) arises by two roots derived from the dorsal divisions of the second and third lumbar nerves. It passes through the psoas major and emerges near the middle of its lateral border. It crosses the iliacus obliquely and then passes through the notch below the anterior superior iliac spine and behind the inguinal ligament to the thigh where it splits into two branches, an anterior and a posterior. The *anterior branch* pierces the fascia lata about four inches below the lateral end of the inguinal ligament and descends along the lateral aspect of the front of the thigh as low as the patella where it joins the patellar plexus. It supplies the skin on the lateral aspect of the thigh. The

*posterior branch* pierces the fascia lata about two inches below the anterior superior iliac spine. It supplies the skin of the lower part of the gluteal region and the lateral aspect of the upper part of the thigh.

(6) The **obturator nerve** (Figs. 238, 288) arises by three roots from the ventral divisions of the second, third and fourth lumbar nerves. It descends through the psoas major and appears at the medial border of the muscle near the back part of the brim of the lesser pelvis. It then passes behind the common iliac vessels and on the lateral side of the hypogastric vessels. Continuing its course along the lateral wall of the lesser pelvis where it lies above the obturator artery it proceeds to the obturator canal through which it passes out of the pelvis. In the obturator canal it divides into an anterior and a posterior branch.

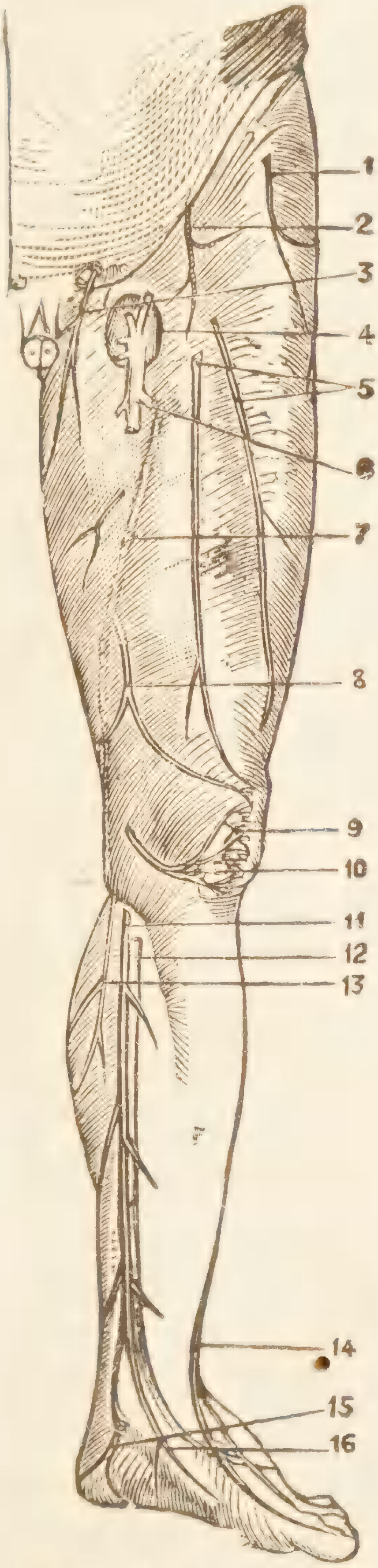
The *anterior branch* passes downwards upon the anterior surface of the adductor brevis and lies under cover of the pectineus and adductor longus. It then descends upon the femoral artery and finally breaks up into minute twigs over its walls. It supplies (*a*) an articular twig to the hip joint ; (*b*) branches to the gracilis, adductor longus and adductor brevis and occasionally to the pectineus ; (*c*) a twig which issues at the lower border of the adductor longus and joins the subsartorial plexus. Occasionally this twig not only sends a filament to the subsartorial plexus but is continued downwards as a cutaneous branch along the posterior border of the sartorius to the medial side of the upper third of the leg. The anterior branch of the obturator nerve is joined by a filament from the accessory obturator nerve, when that nerve is present.

The *posterior branch* passes through the obturator externus and supplies it. It then descends behind the adductor brevis and in front of the adductor magnus and ends by supplying branches to the latter muscle. It gives an *articular branch* ; this branch pierces the adductor magnus above the opening for the femoral vessels and accompanies the popliteal artery descending along its posterior aspect to the popliteal fossa where it pierces the oblique popliteal ligament of the knee joint at about its centre and supplies the articular capsule.

(7) The **accessory obturator nerve** is occasionally found. It arises either from the obturator nerve or from the ventral divisions of the third and fourth lumbar nerves. It passes downwards along the medial border of the psoas major and reaches the thigh by crossing the superior ramus of the os pubis under cover of pectineus. It supplies a twig to the hip joint and ends by joining the anterior branch of the obturator nerve. Occasionally it supplies a twig to the pectineus.

(8) The **femoral nerve** (anterior crural nerve) (Figs. 238, 288) is the largest branch of the lumbar plexus and is formed in the substance of the psoas major by the union of the three dorsal branches of the anterior divisions of the second, third and fourth lumbar nerves. It runs downwards through the psoas major

and emerges at the lower part of the lateral border of the muscle. Next it descends between the psoas major and iliacus, passes beneath the inguinal ligament and enters the femoral triangle where it lies lateral to the femoral artery and is separated from the artery by a small portion of the psoas major. It soon divides into an anterior and a posterior division. In the abdomen, the femoral nerve gives off a muscular branch to the iliacus and a vascular branch which supplies the upper part of the femoral artery. The *anterior division* gives off muscular and cutaneous branches. The *muscular branches* are :—(1) The *nerve to the*



1. Lateral femoral cutaneous nerve.
2. Lumboinguinal nerve.
3. Ilioinguinal nerve.
4. Fossa ovalis.
5. Intermediate femoral cutaneous nerve.
6. Great saphenous vein.
7. Medial femoral cutaneous nerve.
8. Anterior branch of medial femoral cutaneous nerve.
9. Patellar plexus of nerves.
10. Infrapatellar nerve.
11. Saphenous nerve.
12. Great saphenous vein.
13. Posterior branch of medial femoral cutaneous nerve.
14. Superficial peroneal nerve.
15. Medial calcaneal nerve.
16. Saphenous nerve (terminal part).

Fig. 287.—Cutaneous nerves of the inferior extremity. Anterior view.

*pectineus* passes medialwards behind the femoral sheath to supply the muscle. (2) The *nerve to the sartorius* arises usually in common with the intermediate femoral cutaneous nerve and supplies the muscle.

The *cutaneous branches* (Fig. 287) are the intermediate and medial femoral cutaneous nerves. (1) The *intermediate femoral cutaneous nerve* (middle cutaneous nerve) becomes cutaneous by piercing the deep fascia in the middle line about four inches below the inguinal ligament. It soon divides into a medial and a lateral branch, both of which descend in front of the thigh as low as the patella and join the patellar plexus. Sometimes the nerve divides beneath the deep fascia into two branches which pierce the deep fascia separately.

(2) The *medial femoral cutaneous nerve* (internal cutaneous nerve) crosses the femoral artery from the lateral to the medial side at the apex of the femoral triangle and divides into three branches; proximal, anterior, and posterior. The *proximal branch* is often represented by two or more filaments which pierce the fascia lata along the line of the great saphenous vein in the upper part of the thigh. The *anterior branch* descends over the sartorius and becomes cutaneous at the anteromedial aspect of the lower third of the thigh; it descends as far as the knee and ends by joining in the formation of the patellar plexus. The *posterior branch* follows the posterior border of the sartorius, pierces the fascia lata over the medial condyle of the femur and is distributed to the integument on the medial side of the leg. The posterior branch forms with filaments from the obturator nerve and saphenous nerve a plexiform network, the *subsartorial plexus*, which is situated on the deep aspect of the sartorius as this muscle forms the roof of the adductor canal.

The *posterior division of the femoral nerve* gives off the saphenous nerve, muscular, and articular branches. The **saphenous nerve** (internal or long saphenous nerve) lies on the lateral side of the femoral artery in the femoral triangle and at the upper part of the adductor canal. At the lower part of the canal it crosses in front of the femoral artery and gains its medial side. It leaves the canal through the lower part of its aponeurotic roof in company with the saphenous branch of the highest genicular artery. It next passes downwards beneath the sartorius and, emerging from beneath that muscle at its posterior border, pierces the deep fascia at the medial side of the knee. It then descends along the medial side of the leg by the side of the great saphenous vein and terminates at the medial side of the dorsum of the foot. Sometimes it can be traced as far as the ball of the great toe. Here it communicates with the medial branch of the superficial peroneal nerve. In the adductor canal it gives off a filament which pierces the aponeurotic roof of the canal and joins the subsartorial plexus. Before piercing the fascia lata it gives off the *infrapatellar branch* at the medial side of the knee which pierces the sartorius and the fascia lata and joins the patellar plexus. The muscular branches of the posterior division are :—

(1) The *nerve to the rectus femoris* enters its deep surface at the upper part and supplies a twig to the hip joint. (2) The *nerve to the vastus medialis* accompanies the saphenous nerve and enters the adductor canal; in the upper part of the adductor canal the nerve lies on the surface of the muscle. Then it enters the substance of the muscle at about its middle and gives off a filament which supplies the knee joint. (3) The *nerve to the vastus lateralis* descends with the descending branch of the lateral femoral circumflex artery, supplies the muscle and sends a twig to supply the knee joint. (4) The *nerve to the vastus intermedius* are two or three in number and enter the anterior surface of the muscle. Of these the most medial filament supplies the articularis genus and the knee joint by passing through the vastus intermedius.

The **patellar plexus** is formed by the communication with each other of the following nerves in front of and around the patella :—(1) the two branches of the intermediate femoral cutaneous nerve in front of the knee along the middle line ; (2) the anterior branch of the lateral femoral cutaneous nerve along the lateral side ; (3) the anterior branch of the medial femoral cutaneous nerve along the medial side ; and (4) the infrapatellar branch of the saphenous nerve below the patella.

## The Sacral Plexus

**Constitution, position** and **relations.**—The nerves entering into the constitution of the sacral plexus (Fig. 289) are the lumbosacral trunk, the anterior divisions of the first and second sacral nerves and the upper branch of the anterior division of the third sacral nerve—the lower branch of the last named nerve is concerned with the formation of the pudendal plexus. The lumbosacral trunk unites with the first sacral nerve to form a loop and the other sacral roots unite to form similar loops. The series of loops formed in this manner constitute the sacral plexus. The plexus lies on the piriformis and behind the pelvic fascia ; the sigmoid colon, ureter and hypogastric vessels lie in front of the plexus ; the superior gluteal artery passes through the first loop while the inferior gluteal artery passes through one of the other loops of the plexus. Beyond the loops the plexus appears as a large flattened mass lying upon the piriformis and ultimately resolving itself into two bands—an upper or sciatic and a lower or pudendal.

The **sciatic band** is very large and receives the lumbosacral trunk, first sacral, greater portion of the second sacral, and upper branch of the third sacral nerves. This band, flattened in the beginning, becomes rounded as it descends and leaves the pelvis through the lower part of the greater sciatic foramen under the name of the sciatic nerve. The **pudendal band** is small and receives fibres from the second, lower branch of the third and fourth sacral nerves. This band leaves the pelvis through the lower part of the greater sciatic foramen under the name of the pudendal nerve.

Except the anterior division of the third sacral nerve, the nerves entering into the formation of the sacral plexus divide into anterior or ventral and posterior or dorsal branches.

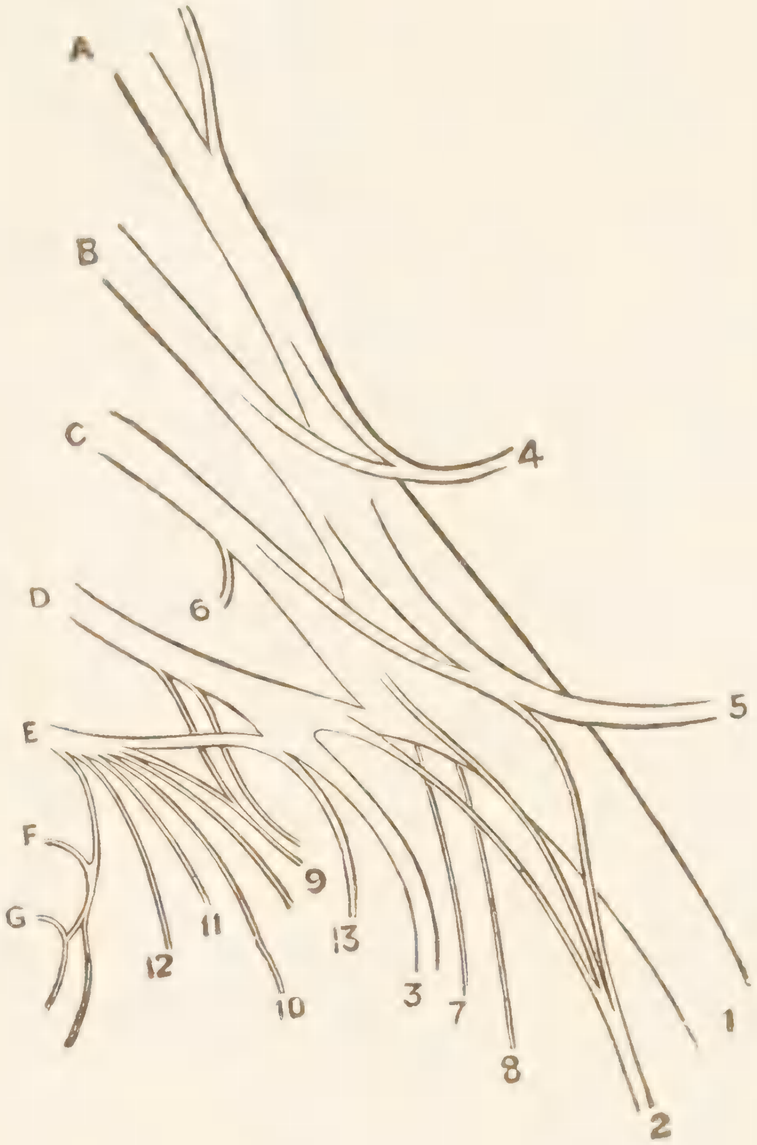


Fig. 289.—Diagram of the sacral, pudendal and coccygeal plexuses.

A. Lumbosacral nerve trunk.
B. First sacral nerve.
C. Second sacral nerve.
D. Third sacral nerve.
E. Fourth sacral nerve.
F. Fifth sacral nerve.
G. Coccygeal nerve.
1. Great sciatic nerve.
2. Posterior femoral cutaneous nerve.
3. Pudendal nerve.
4. Superior gluteal nerve.
5. Inferior gluteal nerve.
6. Branch to piriformis.
7. Nerve to obturator internus.
8. Nerve to quadratus femoris.
9. Visceral branches of third and fourth sacral nerves.
10. Branch to levator ani.
11. Branch to coccygeus.
12. Perineal branch of fourth sacral nerve.
13. Perforating cutaneous branch.

## The Branches of the Sacral Plexus

| Anterior or Ventral Branches | Posterior or Dorsal Branches |
|---|---|
| Posterior femoral cutaneous (S. 2, 3). | Superior gluteal (L. 4, 5, S. 1). |
| Tibial (L. 4, 5, S. 1, 2, 3). | Inferior gluteal (L. 5, S. 1, 2). |
| Nerve to obturator internus and gemellus superior (L. 5, S. 1, 2). | Common peroneal (L. 4, 5, S. 1, 2). |
| Nerve to quadratus femoris and gemellus inferior (L. 4, 5, S. 1). | Posterior femoral cutaneous (S. 1, 2). |
| | Nerve to piriformis (S. 2). |
| | .. .. .. |

The **superior gluteal nerve** arises from the posterior aspect of the lumbosacral trunk and the first sacral nerve. It issues out of the pelvis through the greater sciatic foramen above the piriformis and immediately divides into a superior and an inferior branch. The *superior branch* accompanies the superior division of the deep branch of the superior gluteal artery and supplies the glutæus minimus. The *inferior branch* accompanies the inferior division of the deep branch of the superior gluteal artery and supplies the glutæus medius and minimus and ends in the tensor fasciæ latæ.

The **inferior gluteal nerve** (Fig. 237) arises from the posterior aspect of the lumbosacral trunk and the first and second sacral nerves. It leaves the pelvis through the greater sciatic foramen below the piriformis and breaks up into many branches which enter the deep surface of the glutæus maximus to supply it.

The **posterior femoral cutaneous nerve** (small sciatic nerve) (Figs. 237, 290) arises in most cases from the junction of the sacral and pudendal plexuses and is derived from the first three sacral nerves. It issues out of the pelvis through the greater sciatic foramen below the piriformis and enters the gluteal region in company with the inferior gluteal vessels under cover of the glutæus maximus. From the lower border of that muscle it runs downwards along the middle line of the back of the thigh being covered only by the deep fascia up to the popliteal fossa. It next pierces the deep fascia of the popliteal fossa a little below its middle and descends along the middle line of the back of the leg by the side of the small saphenous vein and terminates about midway between the knee and ankle. **Branches.**—The posterior femoral cutaneons nerve is purely cutaneous and supplies branches to the gluteal region, perineum, back of the thigh, popliteal fossa, and back of the leg. The *gluteal branches* are three or four twigs which turn round the lower border of the glutæus maximus lateral to the ischial tuberosity and ascend to supply the skin of the lower and lateral parts of the gluteal region. The *perineal branches* supply the skin of the upper and medial aspects of the thigh. One of these branches is longer than the others and is called the *long perineal nerve* (long pudendal nerve). It passes medialwards below and in front of the ischial tuberosity. It then pierces the fascia lata about an inch in front of the ischial tuberosity lateral to the margin of the pubic arch, passes forwards beneath the superficial fascia of the perineum and ends in the skin of the scrotum in the male and of the labium majus in the female communicating with the posterior scrotal or labial and inferior hæmorrhoidal nerves. The branches to the popliteal fossa and back of the thigh and leg consist of numerous twigs which supply the skin covering these parts.

The **nerve to the obturator internus** and **gemellus superior** arises from the front aspect of the lumbosacral trunk and the first and second sacral nerves. It leaves the pelvis through the greater sciatic foramen below the piriformis. After giving a branch to the gemellus superior it crosses the ischial spine on the lateral side of the internal pudendal vessels, re-enters the pelvis through the lesser sciatic foramen and reaches the pelvic surface of the obturator internus.

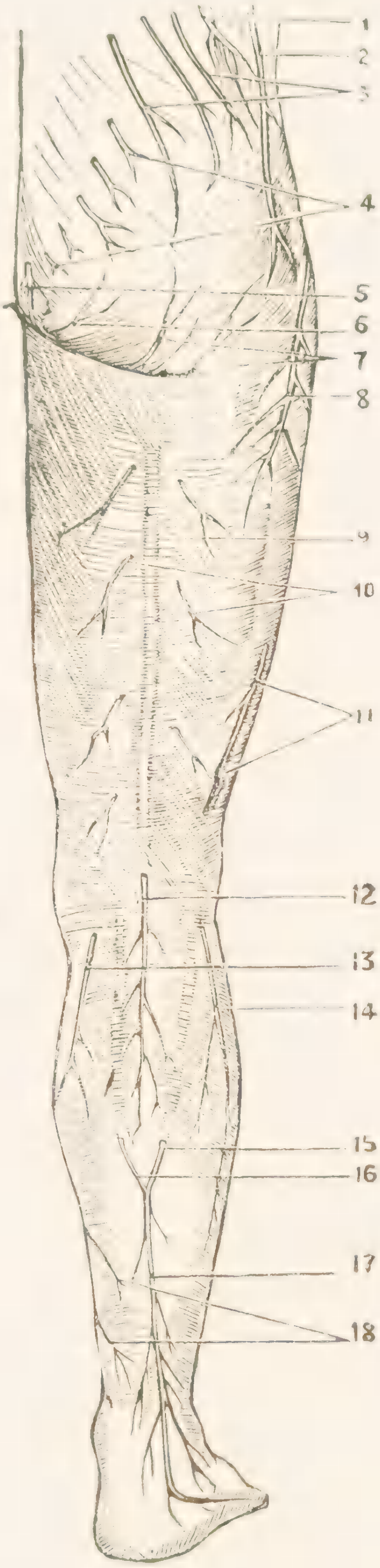


Fig. 290.—Cutaneous nerves of the inferior extremity. Posterior view.

1. Lateral cutaneous branch of iliohypogastric nerve.
2. Lateral cutaneous branch of 12th thoracic nerve.
3. Lateral branches of the posterior divisions of 1st, 2nd, and 3rd lumbar nerves.
4. Lateral branches of posterior divisions of 1st, 2nd, and 3rd sacral nerves.
5. Coccygeal nerve.
6. Perforating cutaneous nerve.
7. Gluteal branches of posterior femoral cutaneous nerve.
8. Posterior branch of lateral femoral cutaneous nerve.
9. Posterior femoral cutaneous nerve.
10. Branches to back of thigh from the above nerve.
11. Lateral femoral cutaneous nerve.
12. Posterior femoral cutaneous nerve.
13. Posterior branch of medial femoral cutaneous nerve.
14. Lateral sural cutaneous nerve.
15. Peroneal anastomotic nerve.
16. Medial sural cutaneous nerve.
17. Sural nerve.
18. Branches of the saphenous nerve.

The **nerve to the quadratus femoris** and **gemellus inferior** arises from the front aspect of the lumbosacral trunk and the first sacral nerve. It leaves the pelvis through the greater sciatic foramen below the piriformis where it lies in contact with the deep surface of the sciatic nerve. It then runs downwards on the bone being covered on its posterior aspect successively by the gemellus superior, obturator internus, gemellus inferior and quadratus femoris. It gives a branch to the gemellus inferior and ends in the deep surface of the quadratus femoris.

The **nerve to the piriformis** arises from the second sacral nerve or from the first and second sacral nerves. It enters the anterior surface of the muscle.

The **sciatic nerve** (great sciatic nerve) (Fig. 237) is the largest nerve in the body and is the continuation of the sciatic band. It arises from the lumbosacral trunk and from the first three sacral nerves. It leaves the pelvis through the greater sciatic foramen below the piriformis and enters the gluteal region where it runs downwards between the greater trochanter of the femur and tuberosity of the ischium accompanied by the inferior gluteal artery and the arteria comitans nervi ischiadici. In the gluteal region the nerve lies in relation posteriorly with the glutæus maximus and anteriorly with the following structures from above downwards :—the posterior surface of the ischium, the nerve to the quadratus femoris, the gemellus superior, the obturator internus, the gemellus inferior, and the quadratus femoris ; it is accompanied by the posterior femoral cutaneous nerve and inferior gluteal artery. The nerve emerges below the lower border of the glutæus maximus and enters the thigh. It descends in the middle line of the back of the thigh lying between the adductor magnus in front and the long head of the biceps femoris behind and divides usually at about the middle of the thigh into two terminal branches, the tibial and the common peroneal nerves. This division may occur at any higher level and the two terminal nerves may be distinct even at their origin.

Although the sciatic nerve apparently looks like a single trunk, in reality it is composed of two nerves viz., the tibial and common peroneal, into which it ultimately terminates. These two nerves are bound together by the same investing sheath and their independent origin can be demonstrated by dissection.

Besides the terminal branches, the sciatic nerve gives off muscular and articular branches. The *muscular branches* arise in the upper part of the thigh and supply the semitendinosus, semimembranosus, long head of the biceps femoris, and adductor magnus and are derived from the tibial portion of the nerve ; the branch to the short head of the biceps femoris arises at a lower level and is derived from the common peroneal portion. The *articular branches* supply the hip joint after perforating the posterior portion of the capsule.

The **tibial nerve** (internal popliteal nerve) (Figs. 237, 240) is the larger of the two terminal branches of the sciatic and is derived from the fourth and fifth lumbar and first three sacral nerves. From its origin from those nerves to the bifurcation of the sciatic nerve, it lies incorporated in the sciatic trunk. It then descends along the back of the thigh and along the middle line of the popliteal fossa to the lower border of the popliteus muscle. Thereafter it descends along the back of the leg to the hollow between the medial malleolus and the heel where it divides under cover of the laciniate ligament into its terminal branches, the medial plantar and lateral plantar nerves. In the thigh it is covered by the hamstring muscles. It emerges from under cover of the biceps femoris and when it enters the popliteal fossa it becomes superficial and lies lateral to the popliteal vessels; in the middle of the fossa it crosses superficial to the vessels and in the lower part of the fossa it runs along their medial side. In the leg it lies upon the tibialis posterior, flexor digitorum longus and lower part of tibia; it is covered in the upper part of the leg by the gastrocnemius and soleus and in the lower part only by the superficial and deep fasciae. It accompanies the posterior tibial artery and lies on the medial side of the vessel for a short distance in the upper part of the leg but it soon crosses superficial to the artery and continues the remainder of its course lying on the lateral side of the vessel.

The **branches** of the tibial nerve are: (1) the medial sural cutaneous, (2) the medial calcaneal, (3) muscular, (4) articular, (5) medial plantar, and (6) lateral plantar.

The *medial sural cutaneous neve* (nervus communicans tibialis) (Fig. 290) arises opposite the middle of the popliteal fossa and runs in the groove between the two heads of the gastrocnemius. It pierces the deep fascia about the middle of the back of the leg and unites with the peroneal anastomotic branch of the common peroneal to form the sural nerve at the lateral border of the upper part of the tendo calcaneus. It supplies the skin of the middle part of the back of the leg. The *sural nerve* (external saphenous nerve) (Fig. 290) runs in company with the distal part of the small saphenous vein, reaches the interval between the calcaneus and lateral malleolus and supplies the skin over the lateral and back aspects of the lower third of the leg. Below the lateral malleolus, the sural nerve runs forwards assuming the name of the *lateral dorsal cutaneous nerve* of the foot and proceeds along the lateral side of the dorsum of the foot and little toe; it communicates medially with the intermediate dorsal cutaneous branch of the superficial peroneal nerve.

The *medial calcaneal branch* pierces the laciniate ligament and is distributed to the skin of the heel and medial margin of the sole of the foot.

The *muscular branches,* arising in the distal part of the popliteal fossa, supply both heads of the gastrocnemius, plantaris, soleus and popliteus. The branch to the popliteus descends along the fascia covering its superficial surface and turns round the lower border of the muscle to gain its deep surface. The branches arising in the leg supply the tibialis posterior, flexor hallucis longus, and flexor digitorum longus.

The *articular branches* are four in number. Three arise in the upper part of the popliteal fossa and supply the knee joint—one accompanies the middle genicular artery; the other two accompany the superior and inferior medial genicular arteries. The fourth branch arises above the terminal divisions of the nerve and supplies the ankle joint.

The **medial plantar nerve** (internal plantar nerve) (Figs. 242, 291) is larger than the lateral plantar nerve. It accompanies the medial plantar artery and has the same course and relations. It arises under cover of the laciniate ligament, passes beneath the abductor hallucis and appears in the interval between this muscle and the flexor digitorum brevis where it ends by dividing into three common digital nerves. **Branches.**—(1) The *muscular branches* arise from the proximal part of the nerve and supply the abductor hallucis and the flexor digitorum brevis. (2) The *cutaneous* branches pierce the plantar aponeurosis at the line of union of its medial and intermediate portions and supply the skin of the sole of the foot. (3) The *proper digital nerve to the medial side of the great toe* supplies the medial side of the great toe and the flexor hallucis bervis. (4) The *three common plantar digital nerves* pass forwards to the clefts between the four medial toes, where each divides into two proper digital nerves. The first common digital nerve supplies a twig to the first lumbrical muscle and its proper digital branches supply the contiguous sides of the great and second toes. The proper digital branches of the second common digital nerve supply the contiguous sides of the second and third toes. The third common digital nerve receives a communicating filament from the superficial branch of the lateral plantar nerve and its proper digital branches supply the contiguous sides of the third and fourth toes. Each proper digital nerve furnishes dorsal twigs for the supply of the nails and tips of the toes. The distribution of these proper digital nerves to the sides and tips of the toes is similar to that of the median nerve in the hand. (5) The *articular branches* supply the tarsal and tarsometatarsal articulations. It will be observed that the medial plantar nerve supplies four muscles viz., the abductor hallucis, flexor digitorum brevis, flexor hallucis brevis and first lumbrical, and also the skin of the three and a half medial toes in the sole of the foot.

The **lateral plantar nerve** (external plantar nerve) (Figs. 242, 291) is smaller than the medial plantar nerve and its distribution is similar to that of the ulnar nerve in the palm. It passes in company with the lateral plantar artery obliquely forwards and lateralwards between the flexor digitorum brevis and quadratus plantæ. Reaching the interval between the flexor digitorum brevis and abductor digiti quinti and opposite the base of the fifth metatarsal bone, it divides into a superficial and a deep branch. The **branches** given off from the trunk of the lateral plantar nerve are:—(1) *muscular branches* to the quadratus plantæ and the abductor digiti quinti; and (2) *cutaneous branches* which perforate the plantar aponeurosis at the line of the union of its lateral and intermediate portions. The *superficial branch* of the lateral plantar nerve divides into a *proper digital nerve* and a *common plantar digital nerve.* The former supplies the lateral side of the little toe, the flexor digiti quinti brevis and the two interosseous muscles of the fourth intermetatarsal space. The latter communicates with the third common digital branch of the medial plantar nerve and divides into two proper digital nerves which supply the contiguous sides of the fourth and fifth toes. The *deep branch* of the lateral plantar nerve accompanies the plantar arch. It rigidly follows the arch, lies posterior to it and ultimately ends in the oblique head of the adductor hallucis. It supplies the second, third, and fourth lumbricales ; both heads of the adductor hallucis ; and all the interosseous muscles except those of the fourth intermetatarsal space. It sends off articular twigs to the tarsal and tarsometatarsal joints.

The **common peroneal nerve** (external popliteal nerve) (Figs. 237, 240) is smaller than the tibial nerve and is derived from the fourth and fifth lumbar and first and second sacral nerves. From its origin from those nerves to the bifurcation of the sciatic, it lies incorporated in the sciatic trunk. It descends along the back of the thigh where it is covered by the biceps femoris and traverses only a portion of the popliteal fossa where it lies along the medial margin of the same muscle. It then leaves the fossa at its lateral angle where it crosses the plantaris and lateral head of the gastrocnemius and finally winding round the neck of the fibula and under cover of the peronæus longus it divides into two terminal branches, the superficial and deep peroneal nerves.

The **branches** of the common peroneal nerve are articular and cutaneous. Of the *articular branches* two accompany the superior and inferior lateral genicular branches of the popliteal artery to the knee joint. The third articular branch, called the *recurrent articular branch*, is given off near the termination of the nerve ; it ascends with the anterior tibial recurrent artery to supply the knee joint. The cutaneous branches are two in number. (1) The *lateral sural cutaneous* nerve supplies the skin over the anterolateral aspect of the upper part of the leg. (2) The *peroneal anastomotic nerve* (nervus communicans fibularis) arises either separately or in common with the preceding nerve. It crosses the lateral head of the gastrocnemius to join the medial sural cutaneous nerve and form the sural nerve.

The **superficial peroneal nerve** (musculocutaneous nerve) (Fig. 241) begins as one of the terminal branches of the common peroneal nerve and descends through the fibres of the peronæus longus to the interval between the peronæus longus and brevis and supplies branches to both the muscles. It then lies between the peronæus brevis and extensor digitorum longus, pierces the deep fascia at the junction of the middle and lower thirds of the leg close to the medial side of the fibula and divides into medial and intermediate dorsal cutaneous nerves. The *medial dorsal cutaneous nerve* divides into two dorsal digital branches. One of these passes to the medial side of the dorsum of the foot, supplies the skin over the part and communicates with the saphenous nerve. It is continued along the medial side of the great toe and also communicates with the terminal part of the deep peroneal nerve at the cleft between the first and second toes. The other dorsal digital branch passes towards the cleft between the second and third toes and divides into two branches which supply the contiguous sides of these toes. The *intermediate dorsal cutaneous nerve* passes along the lateral side of the dorsum of the foot and divides into two dorsal digital branches ; one of which bifurcates to supply the contiguous sides of the third and fourth toes while the other bifurcates to supply the contiguous sides of the fourth and fifth toes. It communicates laterally with the lateral dorsal cutaneous nerve.

It will be observed that the superficial peroneal nerve supplies two muscles, the peronæus longus and brevis, and also the skin of the dorsal aspects of all the toes, except the lateral side of the little toe which is supplied by the lateral dorsal cutaneous nerve (continuation of the sural nerve), and the adjoining sides of the great and second toes which are supplied by the medial branch of the deep peroneal nerve.

The **deep peroneal nerve** (anterior tibial nerve) (Fig. 241) begins as one of the terminal branches of the common peroneal nerve, between the neck of the fibula and the upper part of the peronæus longus. It passes forwards, pierces the extensor digitorum longus and gains the front of the interosseous membrane. It descends over the membrane and lies on the lateral side of the anterior tibial artery at the upper third of the leg. Opposite the middle third of the leg the nerve overlaps the artery and near the ankle again lies to its lateral side. Then it passes behind the transverse crural and cruciate crural ligments and, reaching the dorsum of the foot, divides into a medial and a lateral terminal branch. In the leg it gives *muscular branches* to the tibialis anterior, extensor digitorum longus, peronæus tertius, extensor hallucis longus, and an *articular branch* to the ankle joint. The *medial terminal branch* proceeds forwards on the lateral side of the dorsalis pedis artery. Reaching the first intermetatarsal space it gives off an interosseous branch which supplies the first dorsal interosseous muscle. It then divides into two dorsal digital nerves which supply the contiguous sides of the great and second toes. The *lateral terminal branch* passes lateralwards beneath the extensor digitorum brevis and presents an enlargement on it like that seen on the dorsal interosseous nerve at the wrist. It supplies the extensor digitorum brevis. Three interosseous branches corresponding to the three lateral interosseous spaces take their origin from the ganglionic enlargement and supply the neighbouring joints. The twig for the second interosseous space sometimes supplies the second dorsal interossesous muscle.

The **pudendal plexus** (Fig. 289) is the third subdivision of the lumbosacral plexus and is not sharply demarcated from the sacral plexus. Although it is composed mainly of the spinal nerves below those which form the sacral plexus, yet as a matter of fact some of its branches arise in conjunction with those of the sacral plexus. In fact the sacral and pudendal plexuses were formerly described as parts of one and the same plexus viz. the sacral plexus. The pudendal plexus lies on the posterior wall of the pelvis and is formed by portions of the anterior divisions of the second, third, and fourth sacral nerves.

### Branches of the Pudendal Plexus

| | | | |
|---|---|---|---|
| Visceral | .. | .. | S. 3, 4 |
| Perforating cutaneous | .. | .. | S. 2, 3 |
| Muscular | .. | .. | S. 4 |
| Pudendal | .. | .. | S. 2, 3, 4 |

The **visceral branches** are derived mainly from the third and fourth sacral nerves. They communicate with the pelvic plexuses of the sympathetic and supply the bladder and rectum and in the female also the vagina.

The **perforating cutaneous nerve** arises from the back aspects of the second and third sacral nerves. It pierces the sacrotuberous ligament and thus leaves the pelvis and, winding round the lower border of the glutæus maximus, supplies the skin over the lower and medial parts of that muscle.

The **muscular branches** arise from the fourth sacral nerve and supply the levator ani, coccygeus and sphincter ani externus. The branch to the sphincter ani externus is known as the *perineal branch of the fourth sacral nerve*; it pierces the sacrotuberous ligament and coccygeus and appears in the ischiorectal fossa between the glutæus maximus and external sphincter; besides supplying the latter muscle it gives off cutaneous filaments which supply the skin between the anus and coccyx.

The **pudendal nerve** (Figs. 133, 237) is the continuation of the pudendal band and is the chief nerve of the perineum. It arises from the second, third, and fourth sacral nerves, passes between the piriformis and coccygeus and leaves the pelvis through the greater sciatic foramen below the sciatic nerve. It then lies upon the back of the spine of the ischium medial to the internal pudendal vessels and entering the perineum through the lesser sciatic foramen, it runs in company with these vessels along the lateral wall of the ischiorectal fossa, being enclosed in a special sheath of the obturator fascia, called *Alcock's canal.* It gives off the inferior hæmorrhoidal nerve in Alcock's canal and then divides into two terminal branches, the perineal nerve and the dorsal nerve of the penis or clitoris.

The *inferior haemorrhoidal nerve* arises sometimes independently from the plexus. It crosses the ischiorectal fossa in company with the inferior hæmorrhoidal vessels towards the anal canal and supplies the sphincter ani externus and the skin around the anus; some of its branches communicate with branches of the perineal nerve.

The **perineal nerve** is the larger of the two terminal branches of the pudendal. It runs in company with the perineal artery and splits into a superficial and a deep division at the front part of the ischiorectal fossa. The superficial division is purely cutaneous and consists of the *posterior scrotal nerves* which are two in number, a medial and a lateral they pierce the inferior fascia of the urogenital diaphragm and pass forwards in company with the posterior scrotal vessels to end in the scrotum. In the female the corresponding nerves are called the *posterior labial nerves* and supply the labium majus. The deep division of the perineal nerve is mainly muscular ; it breaks up into branches which supply the bulbocavernosus, ischiocavernosus, transversus perinei superficialis, transversus perinei profundus, and sphincter urethræ membranaceæ. One of these branches, the *nerve to the urethral bulb*, pierces the bulbocavernosus and supplies the corpus cavernosum urethræ as well as the mucous membrane of the urethra.

The *dorsal nerve of the penis* accompanies the internal pudendal artery between the two fasciæ of the urogenital diaphragm lying close to the side of the pubic arch. Piercing the inferior fascia of the diaphragm, about ½ inch below the symphysis pubis, it runs forwards between the two laminæ of the suspensory ligament to the dorsum of the penis, lying on the lateral side of the dorsal artery of the penis and terminates in the glans penis. At the root of the penis it gives off one or two twigs to the corpus cavernosum penis. In the female the corresponding nerve is called the *dorsal nerve of the clitoris* and is very small ; it supplies the clitoris.

The **coccygeal plexus** (Fig. 289) is formed by a filament from the anterior division of the fourth sacral nerve joining the anterior division of the fifth sacral nerve and the coccygeal nerve. From this plexus a few filaments, the *anococcygeal nerves*, proceed to perforate the sacrotuberous ligament and supply the skin of the coccygeal region. Twigs from the fifth sacral nerve supply the coccygeus.

## THE AUTONOMIC NERVOUS SYSTEM

The term **autonomic nervous system** denotes the efferent nervous system of the involuntary muscles, blood vessels, viscera and glands of the whole body. It is not an anatomical subdivision of the whole nervous system but is only a functional differentiation. Like the cerebrospinal axis it consists of a central and a peripheral part. The central part consists of groups of nerve cells situated in the mid-brain, hind-brain, and in the thoracic, lumbar, and sacral portions of the medulla spinalis. From these nerve cells fibres issue and pass out incorporated with some cerebral and spinal nerves and constitute the peripheral portion of the system. The autonomic system is subdivided into two secondary systems : the parasympathetic and the sympathetic.

The **parasympathetic system** consists of a cranial and a sacral portion. The *cranial portion* of the parasympathetic consists of groups of nerve cells situated in the midbrain and hind brain from which autonomic nerve fibres issue and pass out incorporated with certain cerebral nerves viz. the oculomotor, facial, glossopharyngeal, vagus, and accessory nerves. The *sacral portion* of the parasympathetic consists of groups of nerve cells situated in the sacral segment of the medulla spinalis from which fibres issue and pass out incorporated with the second, third, and fourth sacral nerves.

The **sympathetic system** consists of a series of ganglia, plexuses, and nerves distributed widely throughout the whole body. The ganglia are divisible into three groups. The first group, constituting by far the most numerous, is situated centrally, lying on either side of the vertebral column and extending from the base of the skull to the coccyx—the successive ganglia are connected together by nervous cords resulting in the formation of a pair of gangliated trunks, called the *sympathetic trunks*. The second group of ganglia is found in connexion with the three great prevertebral plexuses which lie within the thoracic, abdominal and pelvic cavities and are termed the cardiac, cœliac, and hypogastric plexuses. The third group is situated in the terminations of the nerves in the viscera. The nerve fibres of the sympathetic system are divisible into two groups : (1) the fibres which proceed from the central nervous system to sympathetic ganglia are called *preganglionic* and are medullated fibres,—these nerve fibres are aggregated to form *white rami communicantes* ; (2) the fibres which arise from the sympathetic ganglia and proceed to their respective destinations are called *postganglionic* and are almost all nonmedullated fibres —these nerve fibres are aggregated to form *grey rami communicantes*.

Functionally the sympathetic system is antagonistic to the parasympathetic system e.g. the sympathetic fibres innervate the dilator of the pupil and thus cause its dilatation whereas the parasympathetic fibres passing with the oculomotor nerve innervate the sphincter of the pupil and thus cause its contraction.

For convenience of description the sympathetic system has been dealt with in the following order : (I) the five portions of the system according to the region in which they are situated viz. (1) cephalic, (2) cervical, (3) thoracic, (4) lumbar, and (5) sacral ; (II) the three great plexuses.

## The Cephalic Portion of the Sympathetic System

The **cephalic portion** of the sympathetic system is the upward prolongation into the cranium of the cervical portion of the sympathetic. It begins from the superior cervical ganglion as the *internal carotid nerve* which accompanies the internal carotid artery and during its passage through the carotid canal divides into two branches, a medial and a lateral. The lateral branch breaks up into filaments to form the *internal carotid plexus* on the lateral side of the artery. The medial branch gives off filaments to the internal carotid plexus and enters the wall of the cavernous sinus to form the *cavernous plexus*. Occasionally a minute ganglion, *carotid ganglion,* is seen in the internal carotid plexus, *Branches of the internal carotid plexus.*—The plexus communicates (1) with the tympanic plexus by the *superior* and *inferior carotico-tympanic branches* which join the tympanic plexus traversing the wall of the carotid canal, (2) with the sphenopalatine ganglion by means of a branch, the *deep petrosal nerve*, which pierces the cartilage filling up the foramen lacerum and joins the greater superficial petrosal nerve forming the *nerve of the pterygoid canal* (Vidian nerve), (3) with the semilunar ganglion, and (4) with the abducent nerve. The plexus distributes twigs to the walls of the internal carotid artery.

The *cavernous plexus* surrounds the internal carotid artery specially on its lower and medial side when it traverses the medial wall of the cavernous sinus. It sends communicating filaments to the oculomotor, trochlear, ophthalmic and abducent nerves; it supplies twigs to the hypophysis and forms the sympathetic root of the ciliary ganglion in the orbit. These branches have been described in relation with the cerebral nerves and the ciliary ganglion. The terminal twigs of the internal carotid and cavernous plexus proceed with their further course over the anterior and middle cerebral arteries; over the anterior communicating artery the sympathetic trunk of the right side joins with that of the left side.

## The Cervical Portion of the Sympathetic System

The **cervical portion** of the sympathetic trunk lies between the internal and common carotid arteries in front and the longus capitis and longus colli muscles behind. It consists of three ganglia linked together by intervening nerve cords and is situated behind the carotid sheath. The ganglia are named superior, middle and inferior according to their situation.

The **superior cervical ganglion** lies behind the internal carotid artery and in front of the longus capitis opposite the second and third cervical vertebræ. It is fusiform in shape and about an inch in length. It communicates with (1) the upper four cervical nerves by grey rami communicantes—hence it may be regarded as formed by the fusion of four ganglia corresponding to these four cervical nerves,—(2) the petrous ganglion of the glossopharyngeal nerve, (3) the jugular ganglion and ganglion nodosum of the vagus nerve, and (4) the hypoglossal nerve. Its *branches* of distribution are:—(1) The *internal carotid nerve* which arises from the upper part of the ganglion and accompanies the internal carotid artery to the carotid canal; this nerve constitutes the upward prolongation into the cranium of the cervical portion of the sympathetic. (2) The *external carotid branches* are several filaments which surround the external carotid artery and form a plexus. From the plexus offsets are given off to (*a*) the branches of the external carotid artery; (*b*) to the glomus caroticum; the filaments over the external maxillary artery supply the sympathetic root to the submaxillary ganglion; the filaments over the middle meningeal artery supply the sympathetic root of the otic ganglion and send a branch, the *external superficial petrosal* *nerve* which proceeds to the genicular ganglion of the facial nerve. (3) The *laryngo-pharyngeal branches* pass to the lateral wall of the pharynx and communicate with the pharyngeal branches of the glossopharyngeal and vagus nerves forming the *pharyngeal plexus*. Some filaments join the superior laryngeal branch of the vagus. (4) The *superior cardiac nerve* arises from the superior cervical ganglion by two or more roots. It passes down the neck behind the common carotid artery. The subsequent course of the two nerves then differ on the two sides. The *right nerve* enters the thorax either in front of or behind the right subclavian artery to the back of the arch of aorta where it terminates in the deep cardiac plexus. The *left nerve* runs in front of the left common carotid artery and after crossing the left side of the arch of the aorta terminates in the superficial cardiac plexus. In the neck the superior cardiac nerve is joined by other filaments from the sympathetic, the external laryngeal, the vagus, and the recurrent nerves.

The **middle cervical ganglion,** the smallest of the three ganglia, lies very close to the inferior thyreoid artery opposite the sixth cervical vertebra. It gives off grey rami communicantes to the fifth and sixth cervical nerves. Hence it may be regarded as formed by the fusion of two ganglia corresponding to those two nerves. It gives off (1) *thyreoid branches* which accompany the inferior thyreoid artery to the thyreoid gland and communicate with the external laryngeal and recurrent nerves. (2) The *middle cardiac nerve* is usually the largest of the three cardiac nerves; on the *right side* it passes behind the common carotid artery, and at the root of the neck proceeds either in front of or behind the right subclavian artery; finally it descends on the trachea and terminates in the right portion of the deep cardiac plexus; on the *left side* it descends between the left common carotid and subclavian arteries and terminates in the left portion of the deep cardiac plexus.

The **inferior cervical ganglion** lies between the transverse process of the seventh cervical vertebra and the neck of the first rib behind the vertebral artery. It may be fused with the first thoracic ganglion. It gives off grey rami communicantes to the seventh and eighth cervical nerves. Hence it may be regarded as formed by the fusion of two ganglia corresponding to those two nerves. It is connected with the middle cervical ganglion by two or more cords. One of these cords passes in front of the subclavian artery forming a loop round it, called the *ansa subclavia* (ansa Vieussenii). It gives off (1) *vascular branches* which surround the subclavian artery and form a plexus around it and its branches; (2) the *inferior cardiac nerve* which descends in front of the trachea and joins the deep cardiac plexus.

## The Thoracic Portion of the Sympathetic System

The **thoracic portion** of the sympathetic trunk (Figs. 232, 279) is usually composed of twelve ganglia linked together by intervening cords. Each ganglion is placed against the head of a rib except the last two which lie on the side of the bodies of the eleventh and twelfth thoracic vertebræ. Sometimes there are ten or eleven ganglia owing to the fusion of two ganglia into one. Each ganglion is connected with the corresponding thoracic spinal nerve by two branches called the rami communicantes. Of the two branches one is grey and the other white. The white ramus communicans comes from the spinal nerve to the sympathetic ganglion and the grey ramus communicans goes from the ganglion to the spinal nerve.

**Branches.**—(1) The *aortic branches* are minute filaments which pass from the upper five ganglia to the wall of the aorta. (2) The *pulmonary branches* pass from the third and fourth ganglia and enter the posterior pulmonary plexus. (3) The *greater splanchnic nerve* is formed by branches from the fifth or sixth to the ninth thoracic ganglia. These branches descend obliquely medialwards by the side of the bodies of the thoracic vertebræ and unite to form the trunk of this nerve which pierces the crus of the diaphragm and ends in the upper part of the cœliac ganglion. Often a ganglion, called the *splanchnic ganglion*, is developed on the nerve before it pierces the diaphragm. (4) The *lesser splanchnic nerve* is usually formed by two branches from the tenth and eleventh thoracic ganglia. It pierces the crus of the diaphragm and ends in the aorticorenal ganglion. (5) The *lowest splanchnic nerve* arises from the twelfth thoracic ganglion, perforates the crus of the diaphragm and terminates in the renal plexus.

### The Abdominal Portion of the Sympathetic System

The **abdominal portion** of the sympathetic trunk (Fig. 233) is continuous above with the thoracic portion behind the medial lumbocostal arch. It is placed on the bodies of the lumbar vertebræ along the medial border of the psoas major muscle. On the right side it lies behind the inferior vena cava and on the left side it lies to the left of the aorta. Below it becomes continuous with the pelvic portion of the sympathetic trunk by passing behind the common iliac artery. In the lumbar portion usually there are four ganglia from which *grey rami communicantes* pass laterally and branches of distribution pass medially. The grey rami communicantes, one from each ganglion, pass from all the four ganglia to the corresponding lumbar spinal nerves. The first and second and sometimes the third lumbar spinal nerves send *white rami communicantes* to the corresponding ganglia. The rami accompany the lumbar arteries. The *branches of distribution* are many filaments which pass medially to form chiefly the aortic plexus, but some pass downwards to join the hypogastric plexus.

### The Pelvic Portion of the Sympathetic Syetem

The **pelvic portion** of the sympathetic trunk lies in front of the sacrum medial to the anterior sacral foramina and has upon it four or five ganglia. Lower down, the trunks of both sides converge and unite in front of the coccyx in a single minute ganglion called the *ganglion impar* or the *coccygeal ganglion*. *Grey rami communicantes* pass from the ganglia to the sacral and coccygeal nerves but this portion of the sympathetic receives no white rami communicantes from the spinal nerves. Some filaments from the upper ganglia join the pelvic plexuses and others accompany the middle sacral artery. From the ganglion impar, filaments are distributed to the glomus coccygeum.

## THE PLEXUSES OF THE SYMPATHETIC

The **smaller plexuses** are associated with the branches of the cervical ganglia of the sympathetic and are named the carotid, cavernous, pharyngeal, thyreoid, vertebral, and subclavian plexuses. These have been already described. The œsophageal and pulmonary plexuses receive filaments from the thoracic ganglia of the sympathetic but as the vagus nerve chiefly contributes to their formation they have been described with that nerve. The **great plexuses** of the sympathetic are situated in the thoracic, abdominal, and pelvic cavities and are named the cardiac, cœliac, and hypogastric plexuses.

### The Cardiac Plexus

The **cardiac plexus** is situated at the base of the heart and is divided into a superficial and a deep part.

The **superficial cardiac plexus** is situated in the concavity of the arch of the aorta and above the bifurcation of the pulmonary artery. It is formed by (1) the superior cardiac branch of the left sympathetic trunk and (2) the lower of the superior cardiac branches of the left vagus nerve. A small ganglion, the *cardiac ganglion of Wrisberg*, is usually found at the point of junction of these two nerves. The superficial cardiac plexus distributes branches (1) to the anterior coronary plexus, (2) to the left anterior pulmonary plexus, and (3) to the right part of the deep cardiac plexus.

The **deep cardiac plexus** is situated behind the arch of the aorta and in front of the trachea above its bifurcation. It consists of a right portion and a left portion which are united with each other by communicating twigs. The *right portion* of the plexus is formed by (1) the three cardiac branches derived from the three cervical ganglia of the right sympathetic trunk, (2) the cervical and thoracic cardiac branches of the right vagus nerve, and (3) the cardiac branches of the right recurrent nerve. It communicates with the superficial cardiac plexus and distributes branches to the right anterior pulmonary plexus, the right atrium, and the right coronary plexus. The *left portion* of the plexus is formed by (1) the middle and lower cardiac branches of the left sympathetic trunk, (2) the upper cervical cardiac branch of the left vagus nerve, and (3) the cardiac branches of the left recurrent nerve. It distributes branches to the left anterior pulmonary plexus, the left atrium, and the left coronary plexus.

It is evident therefore that all the cardiac branches from the two vagus nerves and from the cervical sympathetic ganglia of the two sides go to form the deep cardiac plexus, except the lower cervical cardiac branch of the left vagus and the cardiac branch of the left superior sympathetic ganglion.

The **anterior coronary plexus** is formed both from the superficial and the deep cardiac plexus. It accompanies the right coronary artery and distributes branches to the right atrium and ventricle. The **posterior coronary plexus** is formed chiefly from the left portion of the deep cardiac plexus and a few filaments are contributed by the right portion. It accompanies the left coronary artery and distributes branches to the left atrium and ventricle.

### The Coeliac Plexus

The **coeliac plexus** (solar plexus) is the largest of the three plexuses of the sympathetic which are seen in front of the vertebral column ; it is situated at the level of the first lumbar vertebra. It consists of a network of nerve fibres and ganglia which lie between the suprarenal glands and in front of the commencement of the abdominal aorta and crura of the diaphragm. It surrounds the origin of the cœliac artery. Of the ganglia the chief are the two *coeliac* or *semilunar ganglia,* one in each half of the plexus. These are the largest ganglia in the body. The right cœliac ganglion is placed beneath the inferior vena cava. Each ganglion is joined by the greater splanchnic nerve of the same side at its upper part while the lower part of the ganglion remains as a separate small ganglion, called the *aortico-renal ganglion,* and is joined by the lesser splanchnic nerve. The cœliac plexus gives off filaments which descend on the abdominal aorta and accommany the various branches of this arterial trunk. The following subsidiary plexuses are derived from the cœliac plexus :—

(1) The *phrenic plexus* accompanies the inferior phrenic artery to the under surface of the diaphragm where it communicates with the phrenic nerve. On the right side a small ganglion called the *ganglion phrenicum* is seen at the point of communication with the phrenic nerve. The plexus gives off branches to suprarenal plexus, inferior vena cava and œsophagus.

(2) The *superior gastric plexus* accompanies the left gastric artery and joins with branches from the left vagus.

(3) The *hepatic plexus* issues from the cœliac plexus, accompanies the hepatic artery to the liver and is also prolonged on the other branches of the hepatic artery. It is joined by filaments from the left vagus nerve. A prolongation of this plexus along the right gastroepiploic artery along the greater curvature of the stomach is called the *inferior gastric plexus.*

(4) The *lienal* or *splenic plexus* accompanies the lienal artery to the spleen and distributes twigs along the various branches of the artery. It is joined by filaments from the right vagus nerve.

(5) The *suprarenal plexus* gets fibres mostly from the cœliac ganglion as also from the cœliac plexus. It accompanies the middle suprarenal artery to the suprarenal gland. It is connected above with the phrenic plexus and below with the renal plexus. A filament from the lowest splanchnic nerve usually joins this plexus and a small ganglion is seen at its point of junction.

(6) The *renal plexus* derives its fibres from the cœliac ganglion,

the cœliac and aortic plexuses. It accompanies the renal artery to the kidney and is joined by the lowest splanchnic nerve. A few small ganglia are found in this plexus. Filaments from it are given to the suprarenal plexus and to the spermatic or ovarian plexus.

(7) The *superior mesenteric plexus* is derived from the cœliac plexus. It surrounds the origin of the superior mesenteric artery where it presents an enlargement called the *superior mesenteric ganglion* ; it accompanies that artery and its branches into the mesentery and is distributed to those portions of the intestinal canal supplied by the artery.

(8) The *abdominal aortic plexus* is placed upon the front and sides of the abdominal aorta between the origins of the superior and inferior mesenteric arteries. It derives its fibres from the cœliac and superior mesenteric plexuses and from the lumbar ganglia of the sympathetic. It furnishes offshoots to the renal, spermatic and inferior mesenteric plexuses. It is continued downwards over the common iliac arteries to form the hypogastric plexuses.

(9) The *spermatic plexus* accompanies the testicular artery to the testis. It derives its fibres from the aortic and renal plexuses. In the female the *ovarian plexus* accompanies the ovarian artery to the ovary.

(10) The *inferior mesenteric plexus* is derived from the aortic plexus. It surrounds the origin of the inferior mesenteric artery where it presents an enlargement called the *inferior mesenteric ganglion* ; it accompanies that artery and its branches and is distributed to those portions of the intestinal canal supplied by the artery.

## The Hypogastric Plexus

The **hypogastric plexus** is the continuation downwards of the aortic plexus and is joined by filaments from the lumbar ganglia. It is situated in front of the body of the last lumbar vertebra between the two common iliac arteries. Below it divides into two lateral portions called the *pelvic plexuses* which descend at the sides of the rectum. They are joined by visceral branches from the third and fourth sacral nerves and by a few filaments from the upper two sacral ganglia of the sympathetic. Each pelvic plexus gives off branches to the pelvic viscera. These branches follow the course of the hypogastric arteries and form subsidiary plexuses which supply (1) the rectum (*haemorrhoidal plexus*) ; (2) the bladder, the ductus deferentes and the seminal vesicles (*vesical plexus*) ; (3) the prostrate gland (*prostatic plexus*). From the prostatic plexus branches pass forwards beneath the pubic arch to the penis and are called the *cavernous nerves.* The *uterine* and *vaginal plexuses* of the female correspond to the prostatic plexus of the male : the former accompanies the uterine artery and is distributed to the surfaces and walls of the uterus ; the latter arises from the lower part of the plexus and contains mainly sacral nerves and is distributed to the walls of the vagina and the clitoris.

# THE ORGANS OF THE SENSES AND THE COMMON INTEGUMENT

The **organs of the senses** constitute the apparatus by which impressions of light, sound, smell and taste are received and then transmitted to the brain. Each sense organ consists of (1) a receptive portion, situated on the periphery of the body, (2) a conductive portion which transmits the impulses, and (3) a central portion which collects the impulses. The conductive and central portions have been dealt with in the Nervous System. The receptive or peripheral portions are described in this chapter and may be divided into (1) those of the special sense of smell, taste, sight, and hearing, and (2) those of general sensations of heat, cold, pressure and pain and these are widely distributed throughout the whole body.

## The Organ of Smell

The **nose** is the peripheral olfactory organ or organ of smell. It is divisible into two portions: an external portion called the *external nose* and an internal portion, the *nasal cavity*.

The **external nose** has the form of a pyramid; its *root* is attached to the forehead; its free extremity is called the *apex*; its *base* presents two orifices called the nostrils or *nares*, separated

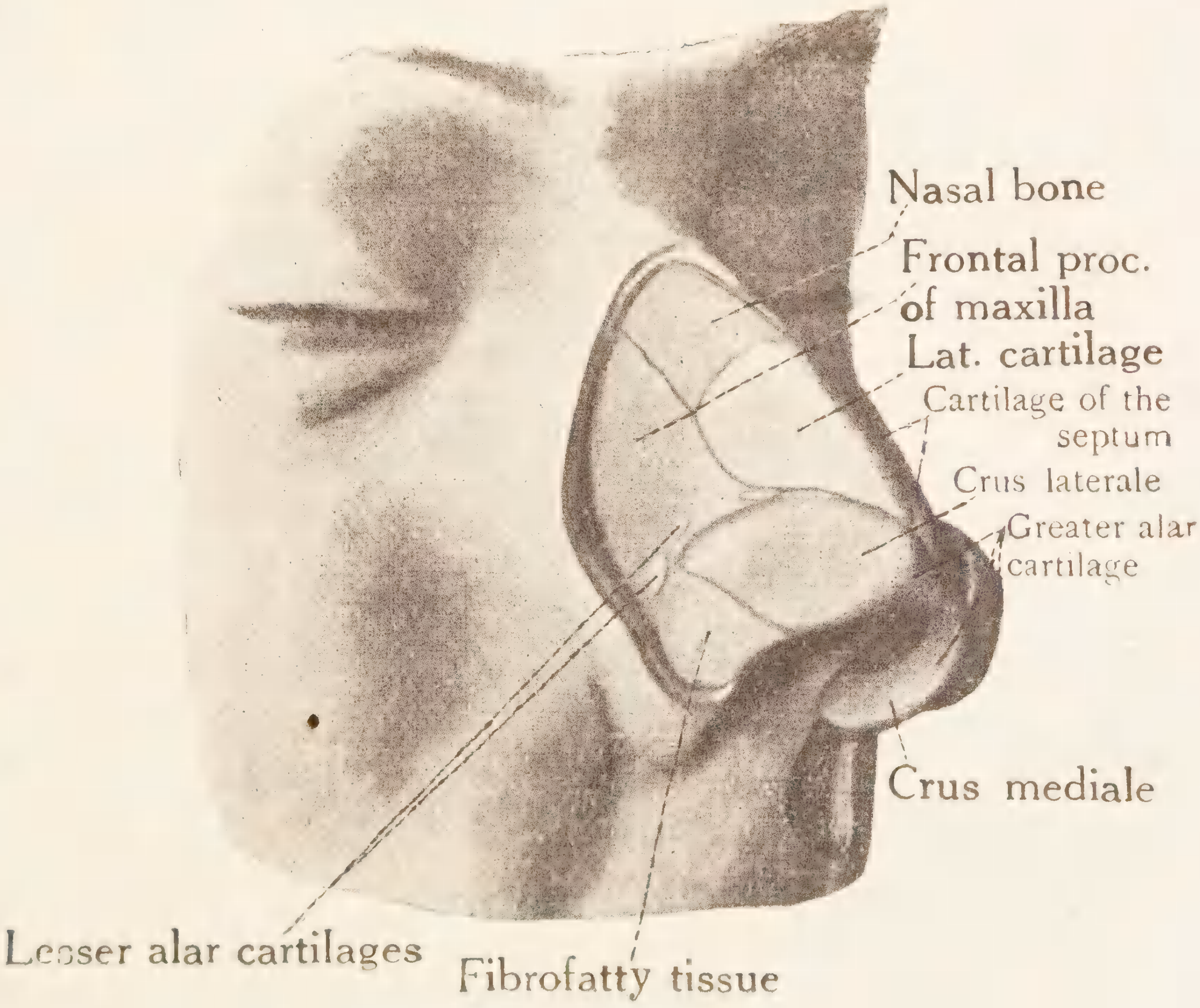


Fig. 292.—The cartilages of the nose.

by a short partition, the *columna*; its lateral surfaces meet anteriorly in a rounded edge, the *dorsum nasi*, the upper part of which is called the *bridge*. Each side of the nose ends below in a rounded eminence called the *ala nasi*. The external nose consists of a bony and a cartilaginous framework. The bony framework has been described in the Section on Osteology. The cartilaginous framework (Fig. 292), consists of five large pieces of cartilage—the two lateral, the two greater alar, and the cartilage of the septum—and some small cartilaginous nodules. These are connected to one another as also to the bony framework by fibrous tissue. The *lateral cartilage* is triangular in shape. Its superior border is attached to the inferior border of the nasal bone and the frontal process of the maxilla by fibrous tissue. Its inferior border is connected with the greater alar cartilage by fibrous tissue. The upper part of its anterior border meets its fellow of the opposite side and the septal cartilage, but lower down a narrow interval is left between the cartilages of the two sides. The *greater alar cartilage* is curved upon itself in such a way as to form the external orifice of the nostril medially, in front, and laterally. Each piece presents a lateral crus and a medial crus. The lateral crus is oval with its long axis directed antero-posteriorly. Above it is attached to the lateral cartilage by fibrous tissue. Behind it is attached to the frontal process of the maxilla by a fibrous membrane in which three or four small pieces of cartilages, called the *lesser alar cartilages*, are embedded. Its lower margin is free. The medial crus is narrow and lies in contact with the medial crus of the opposite side along the middle line connected by fibrous tissue. The *cartilage of the septum* is somewhat quadrilateral in shape. Its posterosuperior border joins the perpendicular lamina of the ethmoidal bone. Its posteroinferior border joins the vomer and the incisive crest of the maxillæ. Its anterosuperior border joins the nasal bones above and the lateral cartilages of the nose below. Its anteroinferior border is connected in front with the medial crura of the greater alar cartilages by fibrous tissue.

The **nasal cavity** is subdivided by the nasal septum into a right and a left nasal cavity; these cavities extend from the nares in front to the choanæ behind. The bony boundaries of the nasal cavities have been described (pp. 76 to 78). The *nares* are pear-shaped apertures separated from each other by a median septum. Above the naris is the *vestibule* of the nose which is a dilated area bounded medially by the lower part of the septum and laterally by the lateral crus of the greater alar cartilage. The vestibule is lined with skin and in its lower part are hairs and sebaceous glands; it is limited superiorly by an arched eminence, the *limen nasi*. The *choanae* are oval apertures which open into the nasal part of the pharynx and look backwards and downwards.

Each nasal cavity is divided into two regions: the *superior* or *olfactory region* is the narrow space included between the superior nasal concha and the opposed part of the nasal septum and comprises the area to which the olfactory nerves are distributed ; the *inferior* or *respiratory region* comprises the rest of the cavity. Each nasal cavity presents for examination a lateral wall, a medial wall or septum, a roof, a floor, an anterior aperture or naris or nostril, and a posterior aperture or choana.

The **lateral wall** (Fig. 293), of the nasal cavity presents in the recent state in front a depression which forms the lateral part of the vestibule of the nose and is lined by skin bearing coarse hairs called *vibrissae.* Behind the vestibular part, the lateral wall presents three elevations covered by mucous membrane. They are called from above downwards the *superior, middle* and *inferior nasal conchæ.* There are recesses below and lateral to these conchæ called the *meatuses.* Above the superior concha is a depression, called the *sphenoethmoidal recess,* into which the sphenoidal sinus opens. The *superior meatus* is a small fissure between the superior concha and the back part of the middle concha. Into its front part the posterior ethmoidal cells open by one or two small apertures. The *middle meatus* is situated between the middle and inferior conchæ. It leads in front into a depression above the vestibule called the *atrium* of the middle meatus which is bounded above by a ridge called the *agger nasi.* Above and in front the middle meatus leads into a funnel-shaped passage called the *infundibulum* by means of which it communicates with the frontal sinus. On raising or cutting away the middle nasal concha a deep curved groove will be seen on the lateral wall of the middle meatus. This groove is called the *hiatus semilunaris* and in it are the openings of the anterior ethmoidal cells and the maxillary sinus. Above the hiatus semilunaris is a rounded elevation called the *bulla ethmoidalis.* The middle ethmoidal cells open either on or above the bulla by an aperture. The *inferior meatus* is the longest of the three meatuses. The nasolacrimal duct opens into its front part.

The **medial wall** of the nasal cavity or **septum nasi** is composed partly of bone and partly of cartilage (p. 77). On the lower and anterior part of the septum, a minute orifice leading into a blind canal, called the *vomeronasal organ of Jacobson,* is seen. This organ corresponds to a similar highly developed structure seen in many lower animals.

The **roof** of the nasal cavity is narrow ; it is horizontal in the middle and sloping both anteriorly and posteriorly. The **floor** is wide, being concave from side to side ; in it and over the incisive foramen is seen a funnel-shaped depression, the *nasopalatine recess,* which represents the communication that existed in early fœtal life between the nasal and buccal cavities.

The **nasal mucous membrane** lines the nasal cavities except the vestibules and is firmly adherent to the subjacent periosteum or perichondrium. It is continuous with the mucous membrane of the nasopharynx through the choanæ ; with the conjunctiva through the nasolacrimal and lacrimal ducts ; and with the mucous lining of the various air sinuses through the apertures of these sinuses communicating with the nasal cavities. It is thick and vascular over the nasal conchæ and also over the septum nasi but is thin in the meatuses and on the floor.

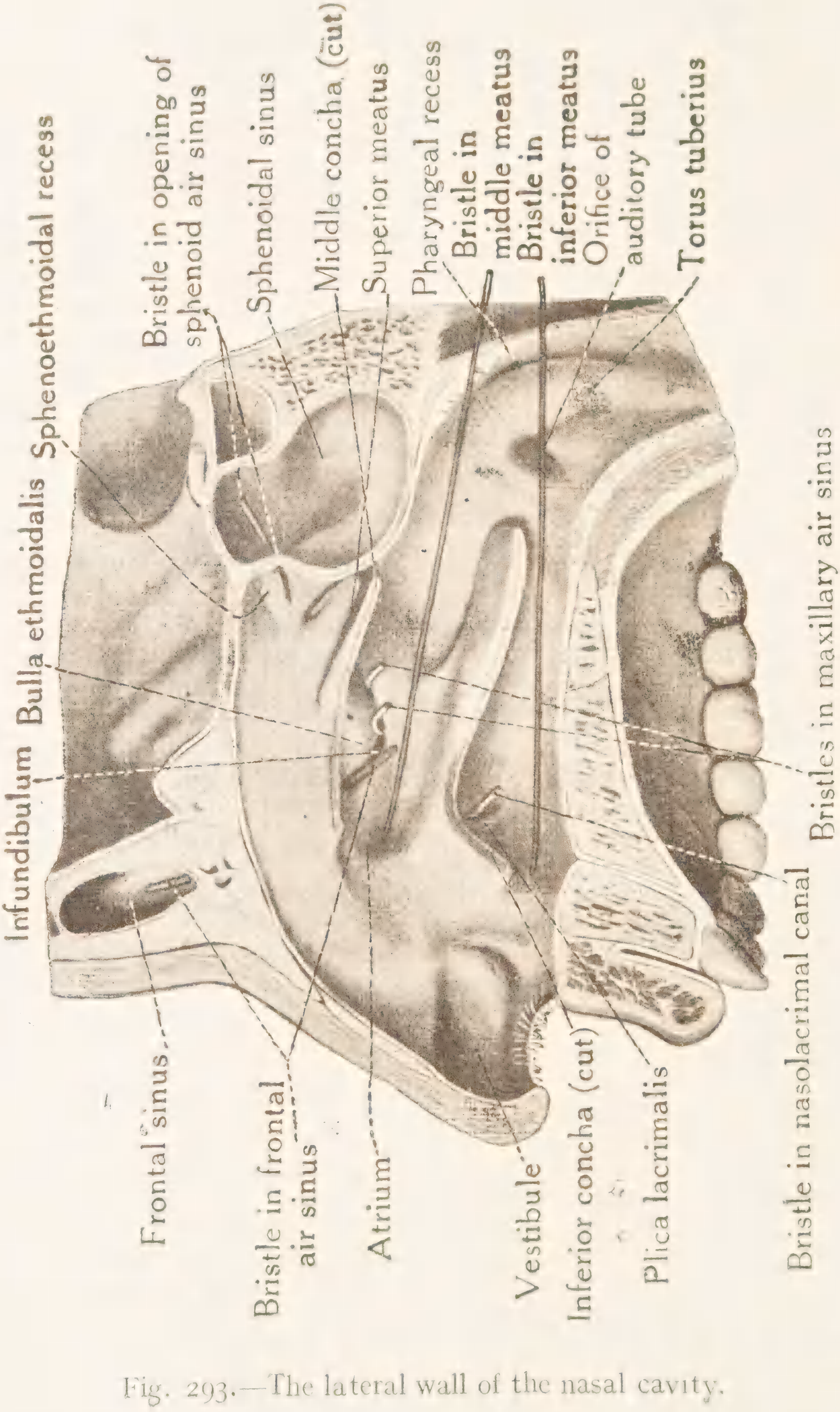


Fig. 293.—The lateral wall of the nasal cavity.

The **paranasal air sinuses** or **accessory sinuses of the nose** have been described on p. 78.

The **arteries** of the nasal cavities are: (1) the sphenopalatine branch of the internal maxillary artery which ramifies over the septum, conchæ and meatuses; (2) the anterior and posterior ethmoidal branches of the ophthalmic artery which supply the roof of the nasal cavity and the frontal and ethmoidal air sinuses; (3) the septal branch of the superior labial artery which supplies the front part of the nasal septum; (4) the pharyngeal branch of the internal maxillary artery which supplies the sphenoidal air sinus; (5) the alveolar and infraorbital branches of the internal maxillary artery which supply the maxillary air sinus. The **veins** form a cavernous plexus beneath the mucous membrane which is pronounced over the inferior concha and over the lower part of the septum. The venous blood is carried into the ethmoidal veins, the anterior facial vein and the pterygoid plexus. The **nerves** of ordinary sensation are derived from the branches of the trigeminal nerve. Those supplying the septum are: (1) the nasopalatine nerve supplies the middle part of the septum; (2) the nasociliary nerve supplies the anterior portion of the septum; (3, 4) some filaments from the sphenopalatine ganglion and from the nerve of the pterygoid canal supply the posterior part of the septum. Those supplying the lateral wall are: (1) the posterior superior nasal branches of the sphenopalatine ganglion, (2) the nasal brach of the anterior superior alveolar nerve, (3) the anterior palatine nerve, and (4) the anterior ethmoidal nerve. The olfactory nerves are distributed over the olfactory region.

## The Organ of Taste

The peripheral gustatory organ or **organ of taste** consists of groups of modified epithelial cells called *gustatory calyculi* or *taste-buds* which are situated on the tongue and neighbouring parts. In the tongue the taste-buds are found mainly on the circumference of the papillæ vallatæ and are found to a slight extent scattered over the fungiform papillæ and throughout the stratified epithelium. They are also present over the fimbriæ linguæ, the oral surface of the soft palate and on the posterior surface of the epiglottis. The *nerves of taste* are: (1) the chorda tympani which is derived from the sensory root of the facial nerve and distributed to the anterior two-thirds of the tongue; (2) the glossopharyngeal nerve which is distributed to the posterior one-third of the tongue.

## The Organ of Sight

The bulb of the eye is the peripheral portion of the organ of sight; associated with it are certain accessory structures viz. the eyebrows, eyelids, conjunctiva, lacrimal apparatus, fasciæ and muscles.

The **bulb of the eye** or **eyeball** lies in the orbital cavity embedded in a mass of fat and enveloped by the fascia bulbi. It is composed of segments of two spheres; the posterior or scleral segment forms about five sixths of the eyeball and the anterior or corneal segment form about one sixth of the globe. The terms *anterior* and *posterior poles* as applied to the eyeball denote the central points of its anterior and posterior curvatures and a line which joins these two poles is called the *optic axis*. An imaginary line drawn midway between the two poles and encircling the eyeball is called the *equator*.

The bulb of the eye consists of three investing tunics and three refracting media. The three tunics are: (1) an outermost fibrous tunic formed by the sclera behind and the cornea in front; (2) an intermediate vascular tunic formed from behind forwards by the chorioid, ciliary body, and iris; and (3) an innermost nervous tunic formed by the retina. The three refracting media are: (1) the aqueous humour in front, (2) the crystalline lens in the middle, and (3) the vitreous body at the back part of the interior of the eyeball.

### The Tunics of the Eye (Fig. 294)

**The sclera** (sclerotic) (Fig. 295) is a dense fibrous membrane which occupies the posterior five-sixths of the eyeball and maintains its shape. It is much thicker behind than in front and is firmly adherent to the chorioid close to the entrance of the optic nerve. Its *external surface* is white and gives attachment to the tendons of the ocular muscles; it lies in contact with the fascia bulbi. It is pierced by the optic nerve about 3 mm. to the medial side of the posterior pole of the eyeball. Here it assumes the appearance of a cribriform lamina, called the *lamina cribrosa sclerae*, which presents minute orifices for the passage of the filaments of the optic nerve. One of the orifices occupies the centre of the lamina

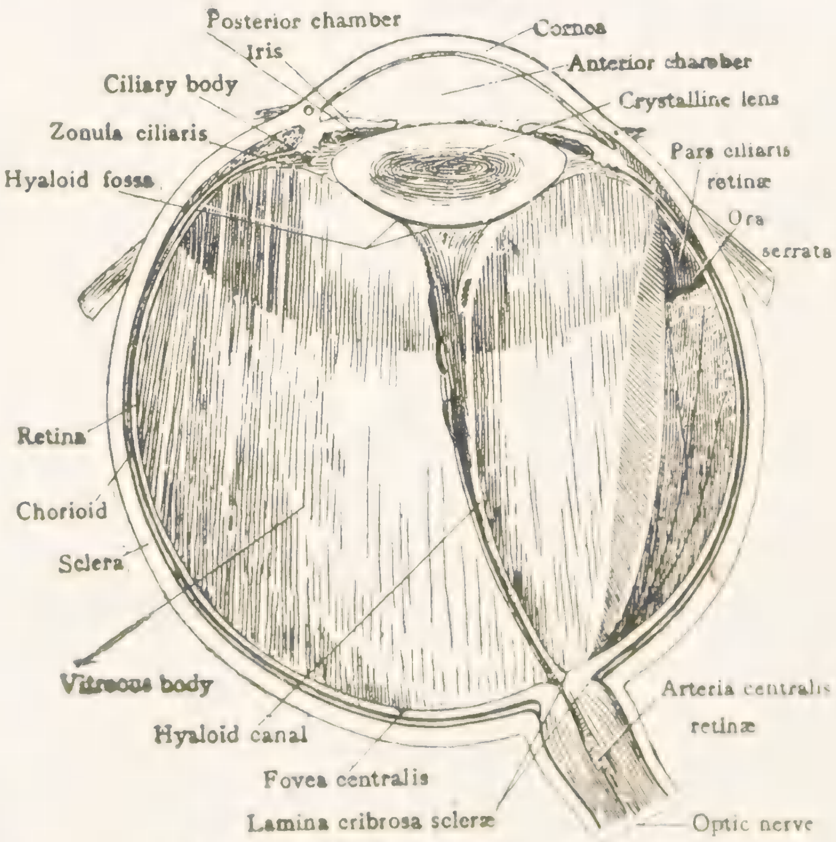


Fig. 294.—Horizontal section of the bulb of the eye.

and transmits the central artery and vein of the retina. Around the lamina are many minute apertures for the passage of the posterior ciliary arteries and ciliary nerves. Almost midway between the entrance of the optic nerve and the sclero-corneal junction are four or five openings for the exit of veins called the *venae vorticosae*. The front part of the sclera is covered by conjunctiva and near its junction with the cornea (*sclero-corneal junction*) it is pierced by the anterior ciliary arteries. Close to the sclerocorneal junction there exists in the substance of the sclera a circular canal called the *sinus venosus sclerae* (canal of Schlemm). In a sagittal section through the eyeball this sinus is seen as a minute opening at the cut margin of the sclera near the sclerocorneal junction.

The *inner surface* of the sclera is smooth. It has a brown colour and presents grooves for the lodgment of ciliary vessels and nerves. Between the inner surface of the sclera and the chorioid is an extensive lymph space, called the *perichorioidal lymph space*; this lymph space is traversed by ciliary vessels and nerves and by pigmented connective tissue called the *lamina suprachorioidea* (lamina fusca) which loosely attaches the sclera to the chorioid.

The **cornea** (Fig. 295) forms the anterior sixth of the external tunic. It is transparent and almost circular and its curvature varies in different individuals. Posteriorly its margin is overlapped by the margin of the sclera. Its anterior surface is convex and covered by conjunctiva which is closely adherent to it. Its posterior surface is concave and covered by a very elastic stratum called the *posterior elastic lamina*. At the sclerocorneal junction the posterior elastic lamina breaks up into fibres forming a meshwork and enclosing a large number of minute spaces between them called the *spatia anguli iridis* (spaces of Fontana). Some of the fibres are prolonged on to the surface of the iris forming the *ligamentum pectinatum iridis*. Others are prolonged backwards to the sclera and chorioid.

The **chorioid** (Fig. 295) is a vascular, darkly-pigmented membrane occupying the posterior five-sixths of the eyeball and is continuous in front with the ciliary body and iris. It is thicker behind than in front. It is pierced behind by the optic nerve. Its outer surface is loosely attached to the sclera by the lamina suprachorioidea. The ciliary nerves run from behind forwards along this surface. The ciliary veins converge to form four or five venous trunks which are situated along the equator of the eyeball at equal distances from each other. These converging veins are called the *venae vorticosae*. Structurally the chorioid practically consists of two layers an outer and an inner. The outer layer is called the *lamina vasculosa* and is formed by the branches of the posterior ciliary arteries and the venæ vorticosæ. The inner layer is called the *lamina choriocapillaris* and is formed by the capillaries of the blood vessels of the outer layer. The inner surface of the chorioid is adherent to the pigmented layer of the retina. In many animals the posterolateral part of the chorioid presents an iridescent appearance. This is due to the presence of another layer in the chorioid called the *tapetum*. This layer is absent in the eyeball of man.

The **ciliary body** (Fig. 296) consists of the orbicularis ciliaris, the ciliary processes, and the ciliary muscle.

The *orbicularis ciliaris* forms a zone of about one sixth of an inch in width. It is continuous with the chorioid, lying immediately in front of it. It presents numerous ridges arranged radially.

The *ciliary processes* form a circle of elongated ridges, about seventy in number. There are also small ridges which occupy the spaces between the large ridges. These ridges are formed by the folding inwards of the layers of the chorioid and they fit into the plications of the suspensory ligament of the lens. They are attached peripherally to the finer ridges of the orbicularis ciliaris and are therefore continuous with the chorioid. Their opposite ends are directed towards the circumference of the lens and are continuous with the periphery of the iris.

The *ciliary muscle* consists of unstriped muscle fibres. It is a circular band about one-eighth of an inch in width, situated in front of the chorioid surrounding the circumference of the iris. It consists of two sets of fibres, meridional and circular, which arise from the sclera near the sclerocorneal junction. The meridional fibres pass backwards to be inserted into the orbicularis ciliaris and ciliary processes. The circular fibres form a ring which is inserted around the circumference of the iris. The ciliary muscle is supplied by the ciliary nerves. *Action.*—It is the muscle of accomodation—it adjusts the eye for vision at near distances. When the meridional fibres contract they pull the chorioid forwards causing relaxation of the suspensory ligament of the lens and hence the anterior surface of the lens becomes more convex by virtue of its elasticity.

The **iris** (Fig. 294) is a thin muscular curtain situated in front of the lens and behind the cornea. It is circular in shape and its colour varies in different individuals. It presents in the centre a circular aperture called the *pupil*. It divides the space between the cornea and lens into two portions, called the *anterior* and *posterior chambers of the eye.* Two sets of involuntary muscle fibres are found in the iris ; (1) the circular fibres which form a band round the pupil called the *sphincter pupillae ;* (2) the radiating fibres which extend from the sphincter to the circumference of the iris in a radiating manner and constitute the *dilator pupillae*. The sphincter pupillæ is supplied by the oculomotor nerve (parasympathetic fibres). The dilator pupillæ is supplied by long ciliary nerves (sympathetic fibres).

A thin vascular membrane, called the *membrana pupillaris*, closes the pupil during the early fœtal life and disappears at birth.

The **retina** (Fig. 297) is the innermost tunic of the eyeball and consists of an outer pigmented layer and an inner nervous layer.

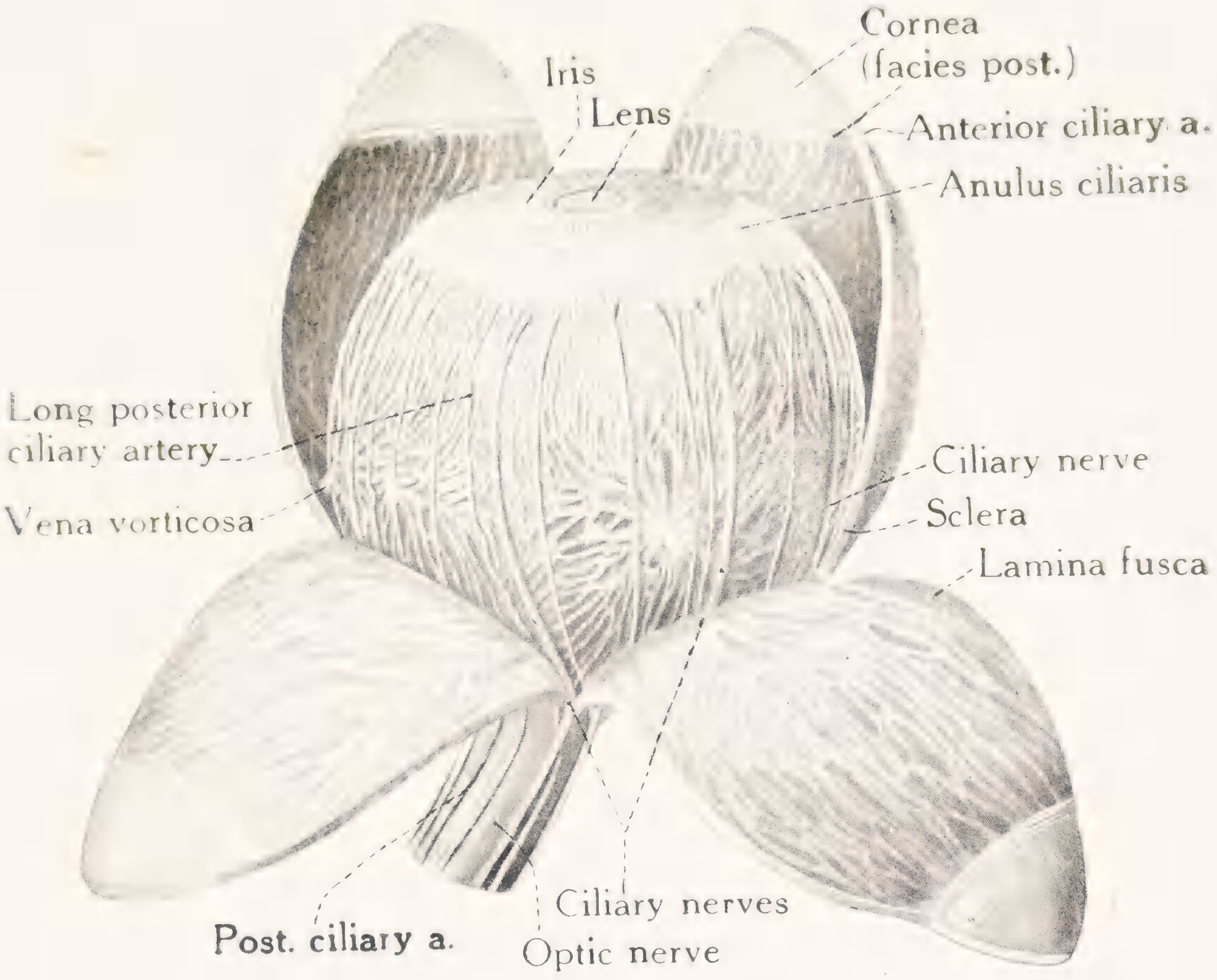


Fig. 295.—Dissection of the eyeball, showing the chorioid, iris, ciliary vessels and nerves.

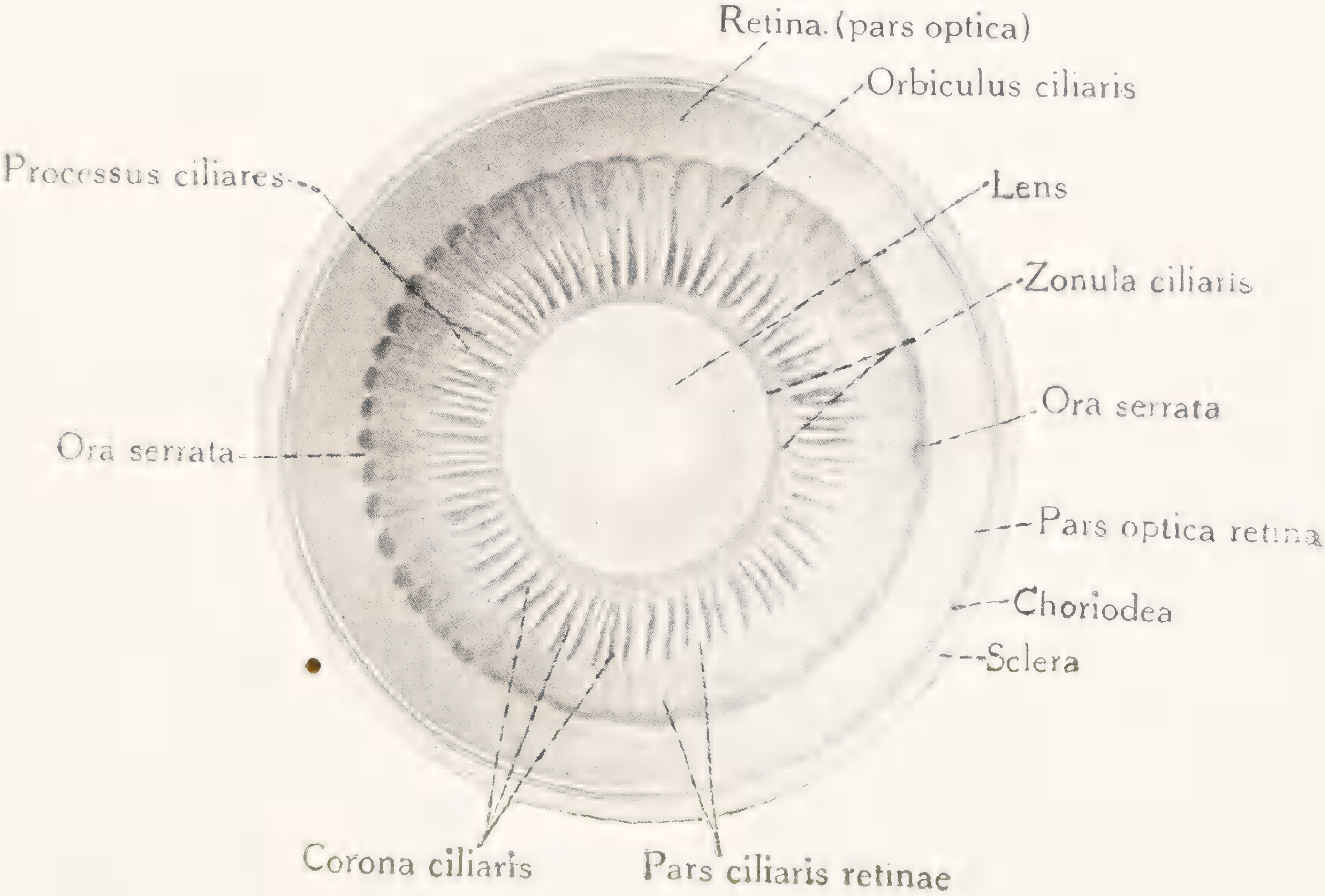


Fig. 296.—Structures seen in the interior of the anterior half of the eye ball.

To face p. 636.

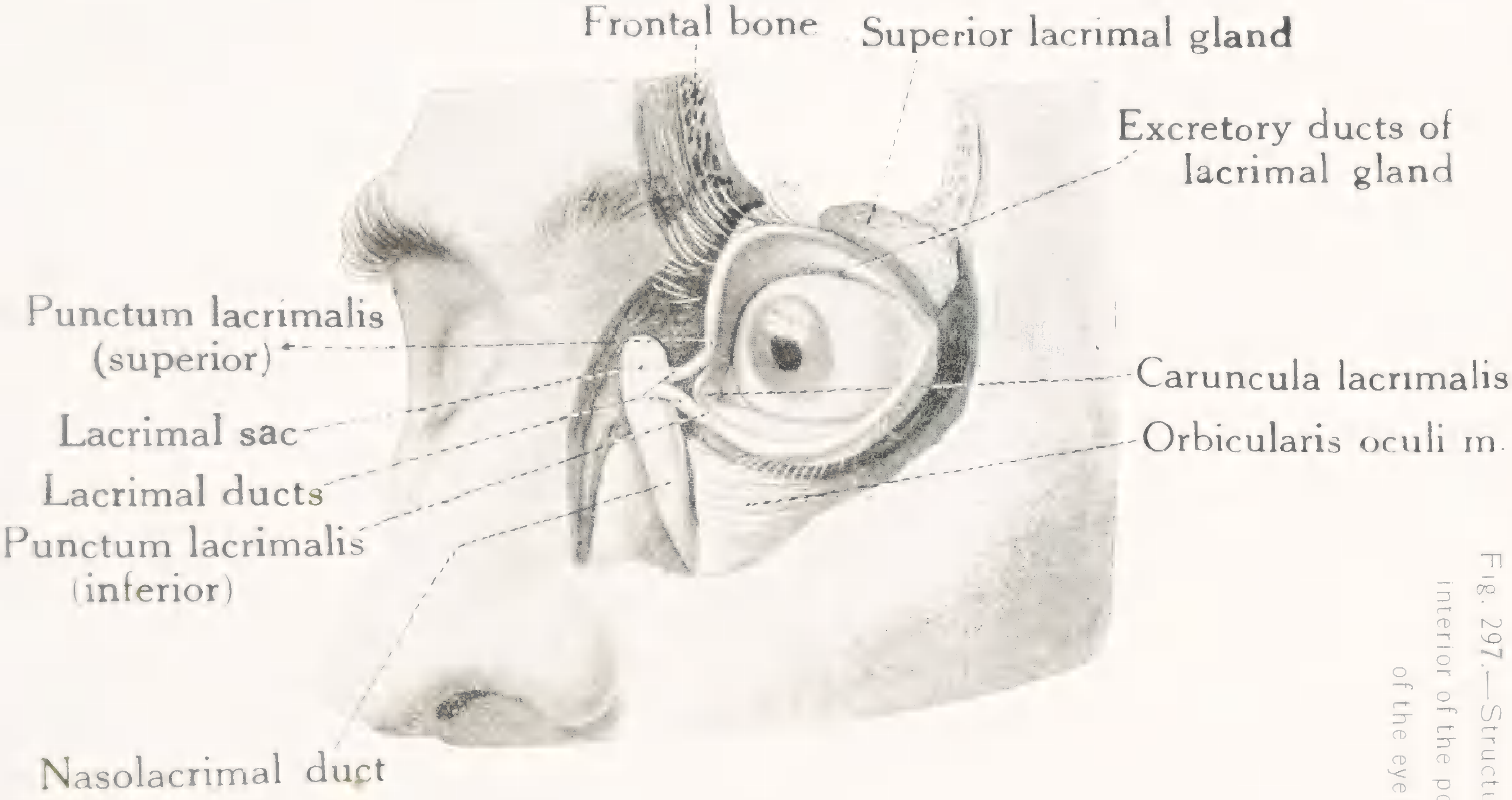


Fig. 298.—The lacrimal apparatus.

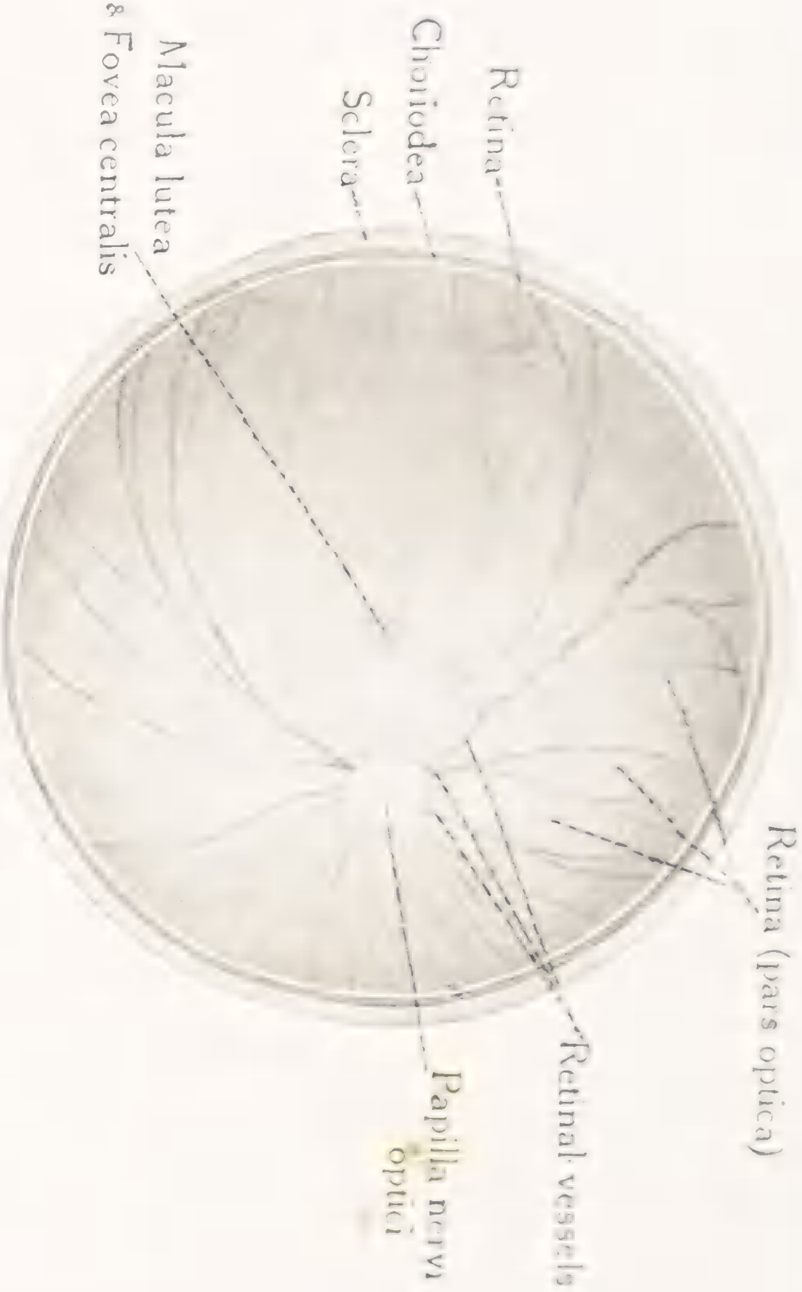


Fig. 297.—Structures seen in the interior of the posterior half of the eye ball.

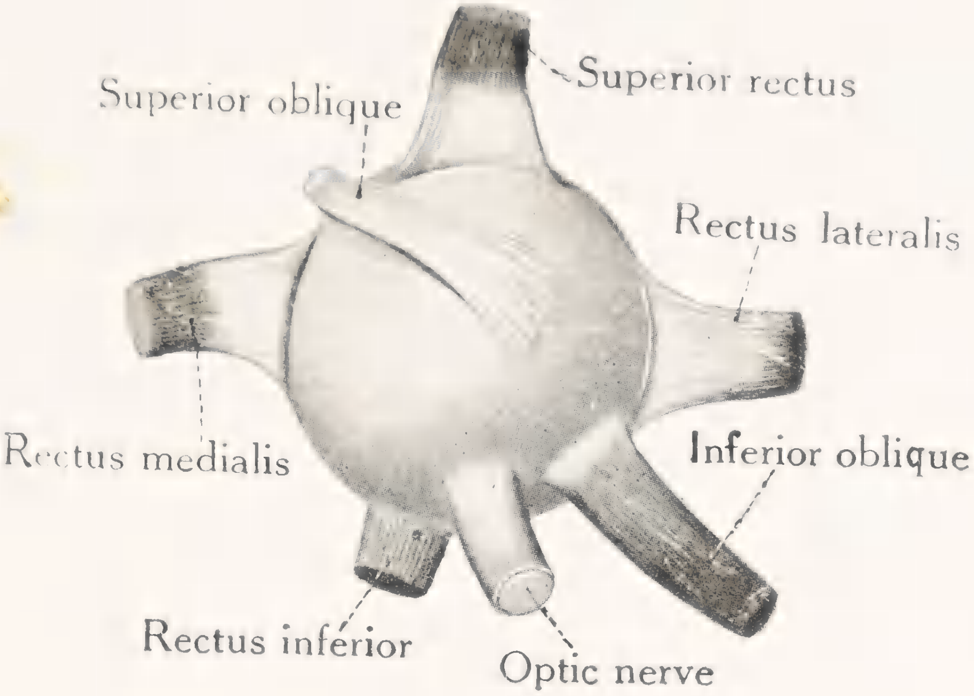


Fig. 299.—Diagram of the ocular muscles.

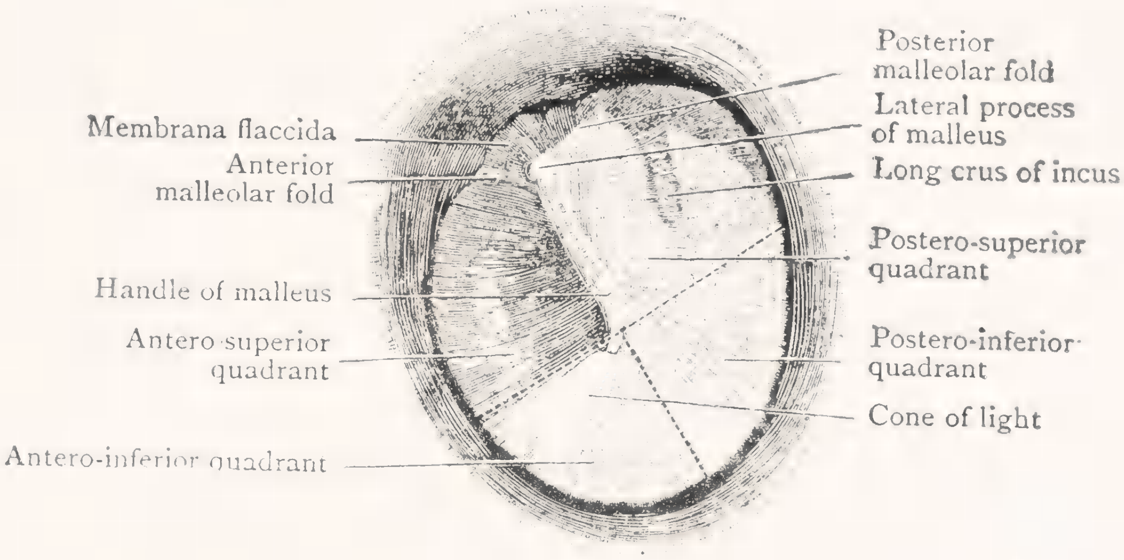


Fig. 302.—The tympanic membrane as seen in an otoscopic examination.

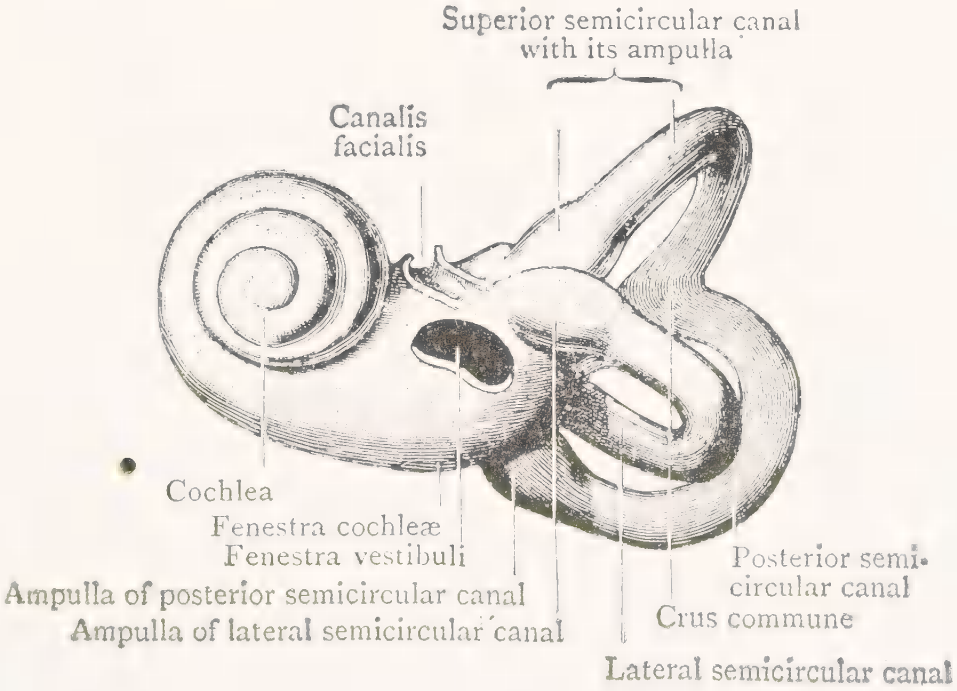

Superior semicircular canal with its ampulla
Canalis facialis
Cochlea
Fenestra cochleæ
Fenestra vestibuli
Ampulla of posterior semicircular canal
Ampulla of lateral semicircular canal
Posterior semicircular canal
Crus commune
Lateral semicircular canal

Fig. 304.—The osseous labyrinth.

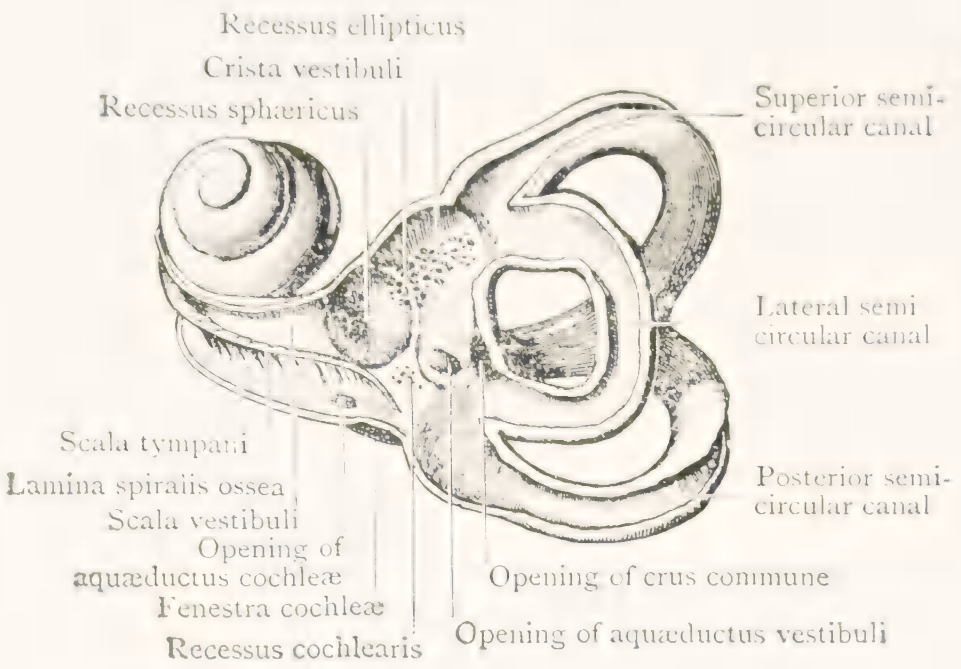


Fig. 305.—The interior of the osseous labyrinth.

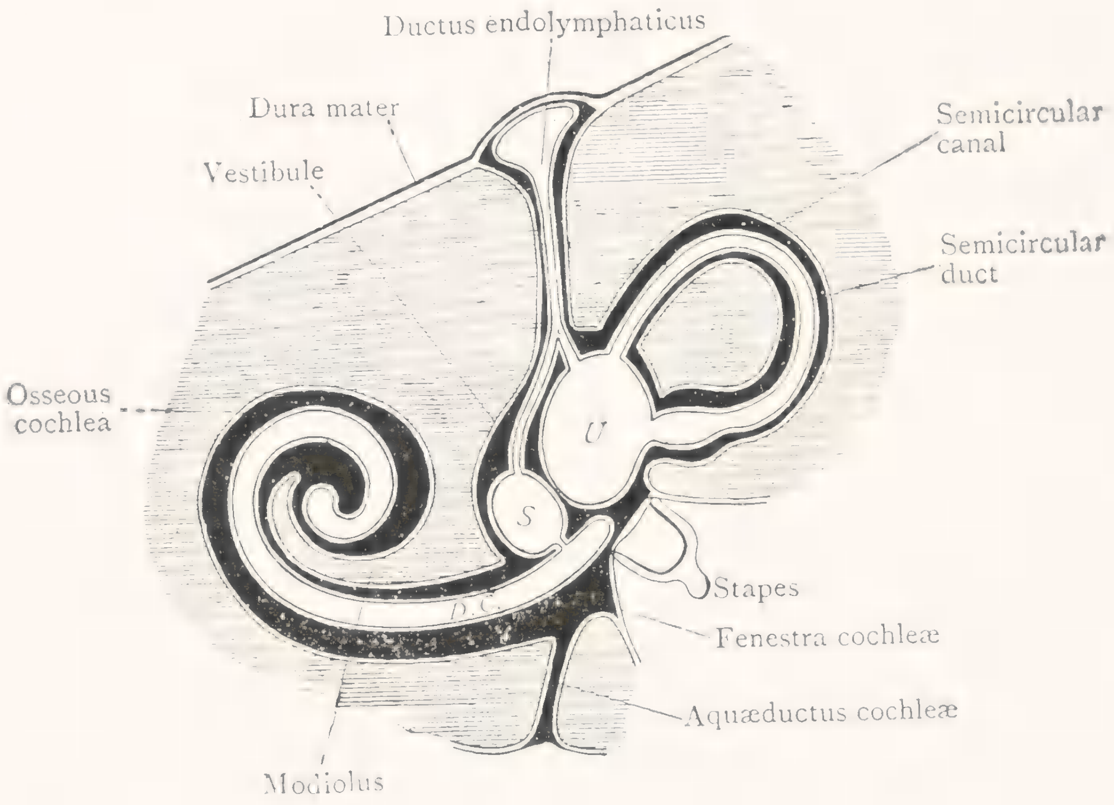


Fig. 306.—Diagram of the osseous and membranous labyrinth.

U. Utricle. S. Saccule. D. C. Ductus cochlearis.

Its outer surface is attached to the chorioid by its pigmentary layer. Its inner surface lies in contact by its nervous layer with the hyaloid membrane of the vitreous body to which however it is not attached except at the entrance of the optic nerve. Anteriorly the retina becomes thinner and near the ciliary body presents an irregular wavy margin called the *ora serrata.* Beyond the ora serrata the nervous elements of the retina cease and its outer pigmentary layer covered by a layer of epithelium is continued forwards over the ciliary processes and the iris forming the *pars ciliaris retinae* and *pars iridica retinae* respectively. At the optic entrance the retina presents the appearance of a circular, whitish disc, *optic disc,* with a slightly raised margin called the *papilla of the optic nerve.* The surface of the disc presents a slight depression called the *excavation of the optic nerve.* At the optic papilla, the optic nerve expands and radiates out so as to form the nervous layer of the retina. The papilla is pierced in the centre by the central artery and vein of the retina. Exactly in the centre of the retina and directly in the optic axis and about one eighth of an inch to the lateral side of the optic entrance, there is a small oval yellowish spot called the *macula lutea* which has a central depression called the *fovea centralis.* The visual sense is most perfect in the macula lutea. The branches of the *arteria centralis retinae* do not anastomse with each other but reach as far as the ora serrata. The *retinal veins* reach the optic papilla from all directions and ultimately unite into one trunk which passes through the substance of the optic nerve.

**Structure.**—The retina consists of two strata, an outer pigmented and an inner nervous or retina proper.

The *pigmented layer* consists of a single layer of hexagonal cells, the outer parts of which are nonpigmented and the inner parts pigmented and extending inwards as fine thread like processes between the rods.

The *nervous layer* is in contact with the hyaloid membrane of the vitreous body and attached to it only around the entrance of the optic nerve and in the region of the ciliary processes. The nervous elements of the retina are supported by nonnervous or sustentacular fibres, and consist of seven layers from within outwards :—

(1) The *stratum opticum* or *layer of nerve fibres* is formed by the fibres of the optic nerve and extends from the optic disc where it is thickest to the ora serrata where it is thinnest. Most of the fibres of this layer are centripetal and begin as axis cylinder processes of the cells of the ganglionic layer; a few are centrifugal and ramify in the inner molecular or inner nuclear layers of the retina.

(2) The *ganglionic* or *nerve cell layer* consists of a single layer of oval cells, except in the macula lutea where several layers are present. From the inner surface of each cell an axon is given off, which is continued as a fibre of the stratum opticum ; from the

outer surface of each cell numerous dendrites arise forming arborizations in the inner molecular layer.

(3) The *inner molecular* or *plexiform layer*, is formed by the interlacing of the dendrites of the cells of the ganglionic layer with those of the inner nuclear layer.

(4) The *inner nuclear layer* or *layer of inner granules* consists of three different types of cells. (*a*) The *bipolar cells*, by far the most numerous, are of two kinds, (i) *rod bipolars* which externally arborize around the ends of the rod fibres and internally end in the cells of the ganglionic layer and (ii) the *cone bipolars* which arborise externally in the outer molecular layer with the foot plates of the cone fibres and ramify internally in the inner molecular layer ; (*b*) the *horizontal cells* which lie immediately internal to the outer molecular layer ; their dendrites pass into the outer plexiform layer and their axons are directed horizontally ; (*c*) the *amacrine cells* which lie in the innermost part of the inner molecular layer.

(5) The *outer molecular* or *plexiform layer* is formed by the interlacing of the dendrites of the bipolar and horizontal cells of the preceding layer with the ends of the rod fibres and the foot plates of the cone fibres.

(6) The *outer nuclear layer* or *layer of outer granules* is made up of several strata of oval cells which are of two kinds, the cone granules and the rod granules. The *cone granules* lie immediately internal to the outer limiting membrane and are continuous with the cones of the next layer ; internally each is prolonged as a straight fibre which, in the outer molecular layer, expands to form a foot plate and arborize with the outer processes of the cone bipolars. The *rod granules* more numerous than the cone granules and are distributed at different levels in this layer ; their external processes are continuous with the rods of the next layer ; their internal processes end in the outer molecular layer where they are in relation with the arborizations of the external rod bipolars.

(7) The *layer of rods and cones* consists of two kinds of structures viz. the rods and the cones. Except at the macula lutea rods are in greater number than the cones. Each rod and cone consists of two segments, inner and outer. The outer segment of each is transversely striated. The inner segments at their outer part present longitudinal striations and at their inner part a granular appearance. The *visual purple* or *rhodopsin* is present only in the outer segments of the rods.

The *sustentacular fibres* of the retina form a framework for the support of the nervous elements. Each begins at the inner surface of the retina in an expanded base which by coalescing with these of the neighbouring fibres from the *membrana limitans interna*. They give off lateral branches, which are few in number in the ganglionic layer and numerous in the inner nuclear layer. In the outer nuclear layer, they break up into numerous filaments forming the *membrana limitans externa* at the bases of the rods and cones.

### The Refracting Media of the Eye (Fig. 294)

The refracting media are three in number, (1) the aqueous humour, (2) the vitreous body, and (3) the crystalline lens.

The **aqueous humour** occupies the space known as the anterior and posterior chambers. It is transparent and composed of water, holding in solution a very small amount of sodium chloride. The *anterior chamber* is bounded in front by the cornea behind by the iris and the central part of the lens, and laterally by the ligamentum pectinatum iridis, where a recess is seen called the *iridial angle* (filtration angle) which leads into the spatia anguli iridis. The *posterior chamber* is bounded in front by the iris, behind by the anterior surface of the lens with its suspensory ligament, and laterally by the ciliary processes. The two chambers communicate through the pupil. The aqueous humour is secreted by the ciliary processes and passes through the iridial angle of the anterior chamber into the anterior ciliary veins.

The **vitreous body** is a transparent jelly-like mass and is composed of water holding in solution a very small quantity of salts and protein. It is enclosed in a delicate, transparent membrane called the *hyaloid membrane.* It fills up the posterior four-fifths of the interior of the eyeball. It presents in front a concavity, called the *hyaloid fossa,* into which the lens is received. A minute canal, called the *hyaloid canal,* runs through the substance of the vitreous body from the region of the optic papilla to the posterior surface of the lens. This canal contains lymph and its wall is formed by a prolongation of the hyaloid membrane. In the embryo it transmits the hyaloid artery to the posterior surface of the lens. Arteries do not enter the vitreous body; its nutrition is carried on by lymph.

The *hyalois membrane* encloses the vitreous body . In front of the ora serrata it is distinctly thick and called the *zonula ciliaris* (zonule of Zinn). The zonula presents a series of alternating elevations and depressions arranged radially. The depressions receive the ciliary processes while the elevations extend into the intervals between these processes. As it approaches the lens it divides into two layers : (1) a thin lamina which lines the hyaloid fossa behind the lens, and (2) a thick layer, called the *suspensory ligament of the lens,* which passes over the ciliary body and becomes attached to the capsule of the lens in front of its equator or circumference. Some fibres of the suspensory ligament are also attached to the equator of the lens. Behind the suspensory ligament and in front of the posterior layer of the zonula ciliaris there is a circular lymph space, called the *spatia zonularia* (canal of Petit) which surrounds the circumference of the lens.

The **crystalline lens** is a biconvex, transparent body placed in front of the vitreous body and behind the iris. It is enclosed within a thin transparent membrane called the *capsule of the lens.* It rests in the hyaloid fossa and is retained in that position by the suspensory ligament. Its anterior surface is less convex than the posterior. Its circumference or *equator* projects into the spatia zonularia. The central points of its anterior and posterior surfaces are called the *anterior* and *posterior poles* and the line joining the two poles is named the *axis*.

**Structure.**—The outer portion of the lens is softer and is called the cortex, whilst the central portion is firmer and is called the nucleus of the lens. From the surface of the hardened lens concentric laminæ can be peeled off like the coats of the onion. These laminæ are the lens fibres formed by the elongation of the cells of the lens.

### The Accessory Organs of the Eye

The accessory organs of the eye are the eyebrows, eyelids, conjunctiva, lacrimal apparatus, fasciæ and ocular muscles.

The **eyebrows** are two curved eminences of the skin placed over the upper margin of the orbit and covered with short stiff hairs. The fibres of the frontalis, corrugator, and orbicularis oculi are inserted into the skin.

The **eyelids** or **palpebrae** are two crescentic folds which cover and protect each eyeball. The upper lid is larger and more movable than the lower one. When the eye is open an elliptical interval between the eyelids is seen called the *palpebral fissure*. When the eyelids are closed the fissure is reduced to a transverse slit. The two eyelids meet at the extremities of the palpebral fissure and form the medial and lateral *palpebral commissures* or *canthi*. At the medial canthus the two eyelids are separated from each other by a triangular interval called the *lacus lacrimalis*. To the free margin of each eyelid lateral to the lacus lacrimalis are attached the *eyelashes*. Behind the attachment of the eyelashes are seen the minute openings of the *ciliary glands*. The margins of the eyelids where they bound the lacus lacrimalis are devoid of eyelashes and ciliary glands and present at their lateral ends an elevation, called the *papilla lacrimalis*, at the summit of which a minute opening is seen, called the *punctum lacrimale*, or the opening of the lacrimal duct.

**Structure of the eyelids.**—The eyelids are composed of the following strata arranged successively from without inwards; (1) skin, (2) subcutaneous tissue, (3) the palpebral portion of the orbicularis oculi, (4) the tarsus, the medial palpebral ligament, the lateral palpebral raphe and the orbital septum—all lying in the same plane; the expanded aponeurosis of the levator palpebræ superioris is present in addition in the upper eyelid only; (5) tarsal glands; and (6) the conjunctiva. The skin is thin, and is continuous with the conjunctiva at the margin of the eyelid. The *subcutaneous areolar tissue* is destitute of fat. The *palpebral portion of the orbicularis oculi* has been described (p. 173).

The **lacrimal apparatus** (Fig. 298) consists of (1) the lacrimal gland by which tears are formed and its excretory ducts by which the tears are conveyed to the surface of the eye; and (2) the lacrimal ducts, the lacrimal sac, and the nasolacrimal duct by which the tears are conveyed to the cavity of the nose.

The **lacrimal gland** lies in a fossa on the front and lateral part of the roof of the orbit. Its size is like that of an almond. Its upper surface is adapted to the concavity of the fossa and is attached to the periosteum lining it by short fibrous bands. Its under surface lies in contact with the convexity of the eyeball. It is partially subdivided into a superior and an inferior portion by the aponeurosis of the levator palpebræ superioris. The superior portion is called the *superior lacrimal gland* and lies above the aponeurosis, while the inferior portion, called the *inferior lacrimal gland*, lies below it. The two portions however are continuous around the lateral edge of the aponeurosis. From their anterior borders fine *excretory ducts*, six to twelve in number, emerge and open into the lateral part of the superior fornix of the conjunctiva. Minute glandular bodies, called *accessory lacrimal glands*, are seen in the neighbourhood of the superior fornix.

The **lacrimal ducts** or **canals** begin as minute orifices, called *puncta lacrimalia*, on the free margins of the eyelids at the lateral extremity of the lacus lacrimalis. The *superior duct*, the shorter and narrower of the two, at first ascends and then proceeds medialwards and slightly downwards to open into the lacrimal sac. The *inferior duct* at first descends and then proceeds horizontally medialwards to open into the lacrimal sac.

The **lacrimal sac** is the dilated upper portion of the nasolacrimal duct. It is oval in shape and lies in the lacrimal fossa formed by the lacrimal bone and the frontal process of the maxilla. Its upper end is closed while below it is continued as a narrow duct called the nasolacrimal duct. The lacrimal ducts open into its anterolateral part. *Relations.*—A fascia, called the *lacrimal fascia*, stretches from the anterior to the posterior lacrimal crest and forms the roof of the lacrimal fossa; the medial palpebral ligament lies in front of, and the lacrimal part of the orbicularis oculi behind, the lacrimal sac.

The **nasolacrimal duct** (nasal duct) is the continuation downwards of the lacrimal sac; it ends in the anterior part of the inferior meatus of the nasal cavity. The opening in the inferior meatus is dilated and surrounded by a fold of the mucous membrane called the *plica lacrimalis*, which acts as a valve. It lies in the bony canal formed by the lacrimal bone, the frontal process of the maxilla, and the lacrimal process of the inferior nasal concha. It is about half an inch in length, and is directed from above downwards, lateralwards and backwards.

The **tarsi** are thin plates of dense connective tissue which give shape to the eyelids. They are two in number, a superior in the upper eyelid and an inferior in the lower eyelid. The *superior tarsus* is the larger and is of a semilunar shape. Its convex superior border and the adjoining anterior surface give attachment to the aponeurotic expansion of the levator palpebræ superioris. Its inferior border is straight and covered by the skin at the free margin of the lid. The *inferior tarsus* is a narrow strip of almost equal breadth throughout. To its inferior border is attached the orbital septum. Its superior border is free. The medial ends of the tarsi are attached to the medial wall of the orbit by the *medial palpebral ligament* (tendo oculi). This ligament is attached medially to the frontal process of the maxilla in front of the lacrimal groove ; laterally it splits into two slips which are attached to the medial ends of both tarsi. The lateral ends of the tarsi are attached to the lateral walls of the orbit by the *lateral palpebral raphe* (external tarsal ligament). This ligamentous band is weaker than the medial palpebral ligament and is attached laterally to the fronto-sphenoidal process of the zygomatic bone ; medially it splits into two slips for attachment to the lateral ends of the two tarsi.

The *orbital septum* or *palpebral fascia* is a membranous sheet which fixes the tarsi to the margins of the orbit, where it is continuous with the periosteum. In the upper eyelid it blends with the superficial lamella of the aponeurosis of the levator palpebræ superioris and is attached to the anterior surface of the upper tarsus. In the lower eyelid it is attached to the inferior border of the lower tarsus. It is pierced by nerves and vessels which leave the orbit.

The *tarsal glands* (Meibomian glands) are situated on the inner surface of the tarsi. If the eyelids are everted they are seen running in vertical yellow strings in grooves on the inner surface of the tarsi. The orifices of these glands are placed behind the eyelashes on the free margins of the lids.

The **conjunctiva** is the mucous membrane lining the inner surface of the eyelids and the front of the eyeball ; the part which lines the eyelids is called the *palpebral conjunctiva,* while that lining the eyeball, the *ocular conjunctiva.* The line along which the conjunctiva lining the eyelids is reflected on to the eyeball is called the *fornix conjunctivae ;* that from the upper eyelid on to the eyeball is called the *superior fornix* and that from the lower eyelid, the *inferior fornix.* At the centre of the lacus lacrimalis there is a small reddish conical elevation, called the *caruncula lacrimalis* with a few tiny hairs attached to it. On the lateral side of the caruncula lacrimalis is seen a vertical fold of the conjunctiva called the *plica semilunaris.* It is the representative of the membrana nictitans or the third eyelid found in birds and many other animals. The cavity of the *conjunctival sac* is a potential space and lies between the eyelids and eyeball. It communicates with the lacrimal sac through the puncta and lacrimal ducts and opens externally through the palpebral fissure.

The **orbital fascia** constitutes the periosteum of the orbit. It is loosely attached to the walls of the orbit and is continuous posteriorly with the dura mater inside the cranial cavity through the superior orbital fissure and the optic foramen. In front it is continuous with the periosteum lining the exterior of the skull. Its connections with the orbital septum have been described.

The **fascia bulbi** (capsule of Tenon) is a membrane which covers the sclera from the optic nerve behind to the sclerocorneal junction in front. Its inner surface is smooth and is separated from the sclera by perischeral lymph space containing loose areolar tissue. Its external surface is covered by the fatty tissue of the orbit. Posteriorly it is pierced by the ciliary vessels and nerves and by the optic nerve with the sheath of which it is continuous. Anteriorly it is blended with the ocular conjunctiva near the margin of the cornea. It is perforated by the tendons of the ocular muscles which are inserted into the sclera and is prolonged backwards on them as tubular sheaths to be continuous with the perimysium of the muscles. The sheath on the superior oblique muscle extends up to its pulley; that on the inferior oblique up to the floor of the orbit. The sheath on the rectus medialis sends a triangular process medialwards to be attached to the lacrimal bone. This is called the *medial check ligament.* Similarly the sheath on the rectus lateralis sends a triangular process to be attached to the zygomatic bone. This is called the *lateral check ligament.* These check ligaments are so called because they check or limit the actions of the two recti. The sheath on the inferior rectus is strengthened and is blended on either side with the check ligaments forming the *suspensory ligament* (Lockwood) which stretches across the anterior part of the orbit below the eyeball like a hammock and is attached medially to the lacrimal bone and laterally to the zygomatic bone. The sheath prolonged on the superior rectus blends superiorly with the tendon of the levator palpebræ superioris.

The **muscles of the eyeball** (Figs. 274, 299) are six in number: two oblique muscles—superior and inferior; and four recti muscles—superior, inferior, medial and lateral; with these is described the levator palpebræ superioris which belongs to the upper eyelid.

The **levator palpebrae superioris** arises from the under surface of the roof of the orbit just above and in front of the optic foramen. It is pointed at its origin and widens in front into an aponeurosis which divides into three lamellæ. The superficial lamella blends with the orbital septum and is attached to the upper part of the anterior surface of the upper tarsus; the intermediate lamella is attached to the superior border of the upper tarsus; the deep lamella, to the upper fornix of the conjunctiva. It is supplied by the superior division of the oculomotor nerve which enters its deep surface. It raises the upper eyelid.

The **superior oblique muscle** arises from the upper and medial margin of the optic foramen above and medial to the origin of the rectus superior. It passes forwards towards the upper and medial angle of the orbit and ends in a tendon which passes through a fibrocartilaginous ring, called the *trochlea* or *pulley*, attached to the fovea trochlearis of the frontal bone. It then suddenly changes its direction downwards, backwards and lateralwards under cover of the superior rectus and becomes inserted into the sclera between the rectus superior and rectus lateralis. It is supplied by the trochlear nerve. It turns the cornea downwards and lateralwards. The trochlea is lined by a mucous sheath which facilitates the movement of the tendon inside it.

The **inferior oblique muscle** arises from a depression on the orbital surface of the maxilla just lateral to the aperture for the nasolacrimal duct. It passes lateralwards, backwards and upwards at first between the inferior rectus and the floor of the orbit, and then between the eyeball and rectus lateralis to be inserted into the lateral aspect of the sclera between the lateral and superior recti. It is supplied by the inferior division of the oculomotor nerve. It turns the cornea upwards and lateralwards.

**Recti muscles.**—A fibrous or tendinous ring surrounds the optic foramen which is the *common tendon of origin* of the four recti muscles. This ring is attached to the upper, medial and lower margins of the optic foramen. From the lower margin it passes lateralwards bridging over the medial end of the superior orbital fissure and becomes attached to the tubercle on the margin of the great wing of the sphenoid forming the lower boundary of the fissure. From this tubercle the band passes to the lateral and upper parts of the optic foramen, thus completing the ring. The upper part of the ring is called the *tendon of Lockwood* and the lower part, the *tendon of Zinn*. The *rectus superior* arises from that part of the fibrous ring which is attached to the upper margin of the optic foramen. The *rectus medialis* arises from the part of the fibrous ring on the medial margin of the optic foramen. The *rectus inferior* arises from the part of the fibrous ring which extends along the lower margin of the optic foramen. The *rectus lateralis* arises by two heads, a superior and an inferior. The superior head arises from the lateral part of the fibrous ring above the optic foramen. The inferior head arises from the lateral part of the fibrous ring below the optic foramen and the tubercle on the great wing of the sphenoid which bounds the superior orbital fissure below. Between these two heads the superior and inferior divisions of the oculomotor nerve, the nasociliary nerve, the abducent nerve and the ophthalmic veins pass. Each rectus muscle is directed forwards and is inserted by a membranous tendon into the sclera about one-fourth of an inch behind the sclero-corneal junction. *Nerve-supply.*—The medial and inferior recti are supplied by the inferior division of the oculomotor nerve; the superior rectus by the superior division of the oculomotor nerve; the rectus lateralis by the abducent nerve. *Actions.*—The rectus medialis turns the cornea medialwards; the rectus inferior, downwards; the rectus lateralis, lateralwards; the rectus superior upwards.

## The Organ of Hearing

The organ of hearing or ear consists of three parts: the external ear, the middle ear, and the internal ear—the peripheral terminations of the acoustic nerve are distributed in the internal ear.

## The External Ear

The **external ear** consists of (1) a fibrocartilaginous expanded portion covered with skin, called the pinna or auricula and (2) the external acoustic meatus.

The **auricula** or **pinna** (Fig. 300) is of an oval form. Its *lateral surface* presents well marked elevations and depressions to which different names have been given. The folded margin of the pinna is called the *helix.* In front of the helix and separated from it by a curved depression, called the *scapha* (fossa of the helix), is another curved prominence called the *antihelix.* The antihelix bifurcates at its upper extremity, presenting a triangular depression between the two diverging limbs called the *fossa triangularis* (fossa of antihelix). The broad deep cavity bounded posteriorly by the antihelix is called the *concha.* The concha is partially subdivided by the *crus* or anterior end of the helix into an upper part called the *cymba conchae* and a lower part called the *cavun conchae.* The conical projection in front of the concha and projecting backwards over the external acoustic

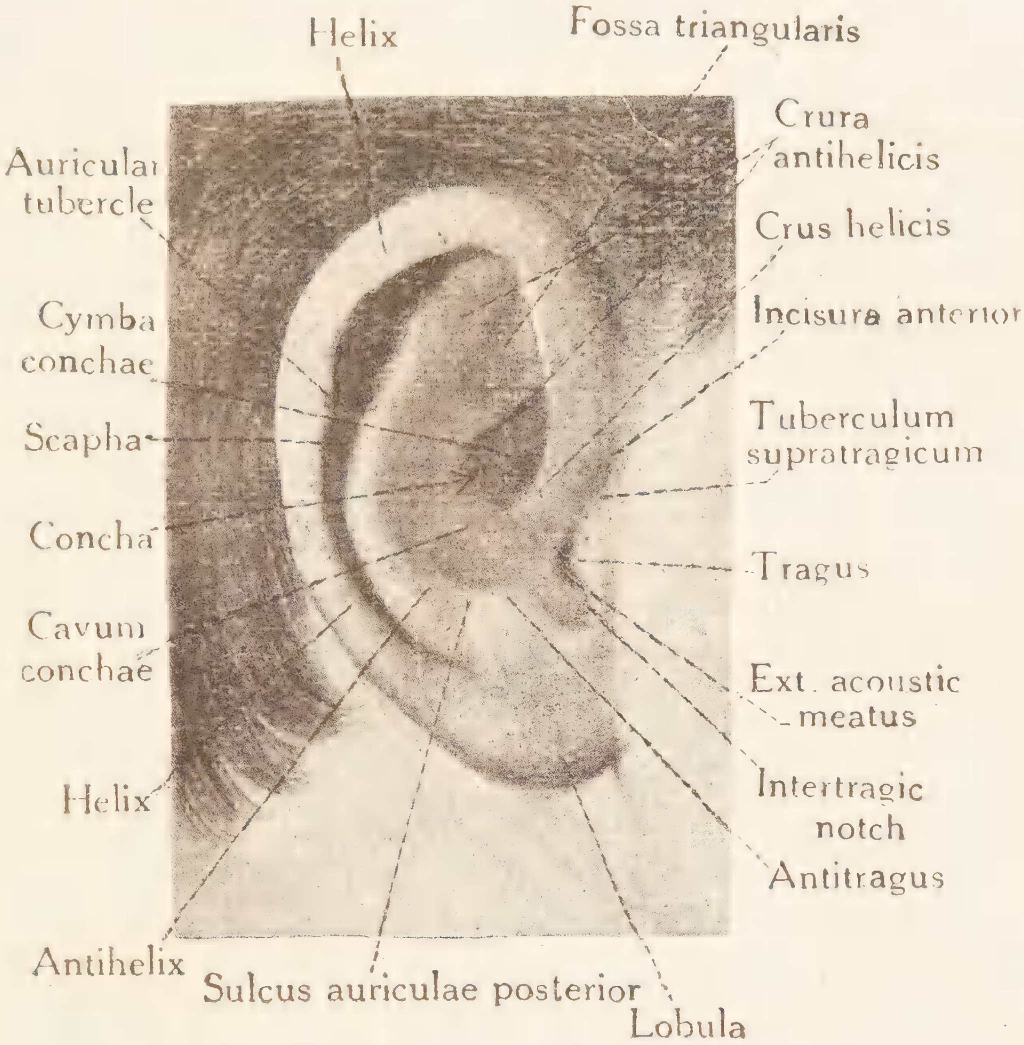


Fig. 300.—The auricula.

meatus is called the *tragus.* Behind the tragus and separated from it by a notch (*intertragic notch*) is another nodule called the *antitragus.* The lowest soft dependent part of the ear is called the *lobule.* The *medial surface* of the auricula presents elevations which correspond to the depressions on the lateral surface and are named eminentia concha, eminentia triangularis etc.

**Structure.**—The auricula consists of a plate of cartilage which is covered by skin and is attached to the side of the head by ligaments and muscles. The *skin* of the auricula is thin and is prolonged as a lining to the external acoustic meatus. It is provided with hairs which are strong and numerous on the tragus and antitragus. The *cartilage* of the auricula extends over the whole auricula as one piece but is absent from the lobule. The helix at the posterior margin of the auricula is prolonged downwards as a tail-like process called the *cauda helicis.* Between this and the antihelix is a fissure called the *fissura antitragohelicina.* A small eminence, called the *spina helicis,* is seen where the helix bends upwards in front. Between the tragus and the helix is a gap in the cartilage which is filled up by dense fibrous tissue. The auricular cartilage is prolonged from the bottom of the concha as a tubular process which is fixed to the margin of the porus acusticus externus of the temporal bone. This forms the cartilaginous portion of the external acoustic meatus. The cartilaginous tube is incomplete being deficient above and posteriorly, the gap being filled up by dense fibrous tissue. The cranial surface of the cartilage of the auricula presents a transverse furrow called the *sulcus antihelicis transversus* which separates the eminentia concha from the eminentia triangularis. The eminentia concha is traversed by a vertical ridge, called the *ponticulus,* to which the auricularis posterior is attached.

The *ligaments of the auricula* are extrinsic and intrinsic. The extrinsic ligaments are three in number. The *anterior* passes from the spina helicis to the root of the zygomatic process of the temporal bone. The *superior* extends from the concha to the temporal fascia. The *posterior* extends from the concha to the outer surface of the mastoid process. There are also several intrinsic ligaments connecting the various parts of the auricular cartilage.

The *muscles of the auricula* are extrinsic and intrinsic. The *extrinsic muscles* have been described (p. 172). The *intrinsic muscles* of the auricula are:—(1) The *helicis major* arises from the spina helicis and is inserted into the anterior margin of the helix. (2) The *helicis minor* covers the lateral surface of the crus helicis. (3) The *tragicus* consists of vertical fibres on the lateral surface of the tragus. (4) The *antitragicus* arises from the lateral surface of the antitragus and is inserted into the antihelix and cauda helicis. (5) The *transversus auriculae* lies on the cranial surface of the auricula and extends from the eminentia concha to the eminentia scapha. (6) The *obliquus auriculae,* also on the cranial surface, extends from the prominence of the concha to the eminentia triangularis. These muscles are supplied by the facial nerve.

The *arteries* of the auricula are (1) anterior auricular branches of the superficial temporal artery, (2) branches from the posterior auricular artery. The *sensory nerves* of the auricula are (1) the great auricular nerve, (2) the auriculotemporal nerve, and (3) the lesser occipital nerve.

The **external acoustic meatus** (external auditory meatus) (Fig. 301) is the passage which extends from the bottom of the concha to the tympanic membrane. Measured from the bottom of the concha it is about an inch in length. Its medial two-thirds are osseous whereas the lateral third is cartilaginous. The entire meatus forms an S-shaped bend and consists of three portions: the *external portion* is directed medialwards, forwards and slightly upwards; the *intermediate portion* is directed medialwards and backwards; the *internal portion* is directed medialwards, forwards and slightly downwards. It is an oval cylindrical canal and its greatest diameter has an inclination downwards and backwards. The canal is widest at its lateral end; its bony portion is narrower than the cartilaginous portion; the narrowest part of the canal, called the *isthmus,* is about one-fifth of an inch lateral to the membrana tympani. The medial end of the canal is closed by the membrana tympani which is placed obliquely in such a way that the anterior wall and the

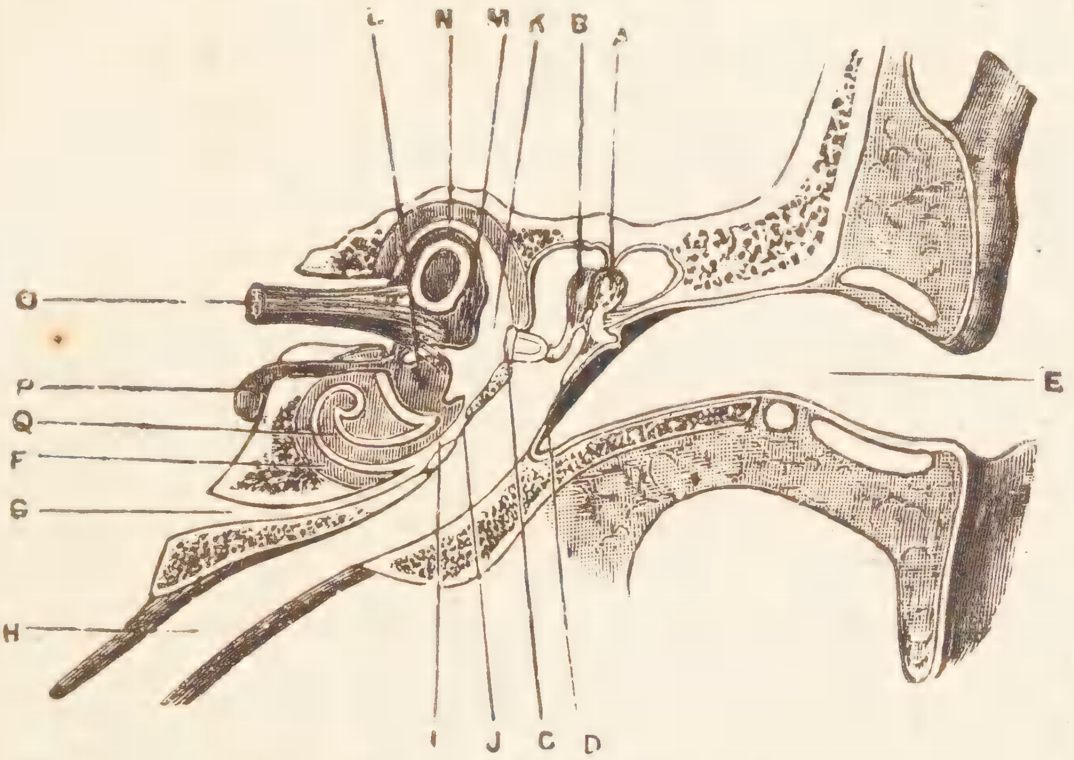


Fig. 301.—Diagram of the auditory apparatus.

A. Malleus.
B. Incus.
C. Stapes.
D. Membrana tympani.
E. External acoustic meatus.
F. Cochlea.
G. Aqueductus cochleæ.
H. Auditory tube.
I. Sçala tympani.
J. Fenestra cochlearis.
K. Perilymph in vestibule.
L. Saccule.
M. Utricle.
N. Superior semicircular canal.
O. Acoustic nerve.
P. Saccus endolymphaticus.
Q. Cochlear canal.

floor of the canal are longer than the posterior wall and the roof. The *osseous part* of the canal has been described (p. 48). The *cartilaginous part* is continuous with the cartilage of the auricula. There is a deficiency in the cartilage at its upper and back part which is filled up by fibrous membrane. The skin lining the external acoustic meatus is prolonged over the lateral surface of the membrana tympani as a thin cuticular layer. In the cartilaginous portion of the canal the skin is covered with hair and the subcutaneous tissue contains the ceruminous glands which secrete the ear wax. The *arterial supply* of the external acoustic meatus is derived from the posterior auricular and superficial temporal arteries and from the deep auricular branch of the internal maxillary artery; the *nerve-supply*, from the auriculotemporal nerve and auricular branch of the vagus nerve.

## The Middle Ear (Fig. 301)

The **tympanic cavity** or **middle ear** is a small air-chamber placed between the membrana tympani and the internal ear; the air is carried to it from the nasopharynx through the auditory tube. The tympanic cavity is divisible into two parts: an upper part lying above the level of the membrana tympani, called the *attic* or *epitympanic recess* which contains the greater part of the incus and the upper half of the malleus; and a lower part called the *tympanic cavity proper* which lies medial to the membrana tympani on a level with it. Including the attic its vertical and antero-posterior diameters are each about half an inch; the transverse diameter is about a sixth of an inch. It is traversed by a chain of bones which extends from its lateral to its medial wall. The tympanic cavity communicates in front with the nasal portion of the pharynx through the auditory tube and behind with the tympanic antrum, and through the antrum with the mastoid air cells.

The tympanic cavity presents for examination six walls. The **tegmental wall** or **roof** is formed by a thin plate of bone, the tegmen tympani, which constitutes a portion of the anterior surface of the petrous part of the temporal bone. It extends backwards to cover the tympanic antrum and forwards to form the roof of the semicanal for the tensor tympani muscle. It separates the tympanic cavity and antrum from the middle fossa of the cranium.

The **jugular wall** or **floor** is narrower than the roof and is formed by a thin plate of bone which separates the tympanic cavity from the jugular fossa and the superior bulb of the internal jugular vein. On it near the medial wall is an opening which gives passage to the tympanic branch of the glossopharyngeal nerve.

The **anterior** or **carotid wall** is narrowed in the vertical diameter by the descent of the roof and the ascent of the carotid canal; it is also narrowed transversely by the convergence of the lateral and medial walls. At its upper part are the openings of two semicanals one above the other, separated by a thin lamina of bone called the septum canalis musculo-tubarii. The semicanals run forwards and downwards and open in the angle of junction of the squama and the petrous part of the temporal bone. The upper and smaller canal is the *semicanalis musculus tensor tympani* and lies immediately below the tegmen tympani. It extends up to the medial wall of the tympanic cavity, where it ends above the anterior part of the fenestra vestibuli. The lower and larger canal is the *semicanalis tubae auditivae* and forms the bony part of the auditory tube. Below the orifice of the auditory tube, the anterior part of the tympanic cavity is separated from the ascending portion of the carotid canal by a thin plate of bone. This plate is perforated by the tympanic branch of the internal carotid artery and by the carotico-tympanic nerves.

The **posterior** or **mastoid wall** presents from above downwards the following parts : (1) At its upper and lateral part is a triangular opening which leads backwards from the attic or epitympanic recess to the tympanic or mastoid antrum. (2) At the postero-inferior part of the epitympanic recess is a depression, called the *fossa incudis* which receives the end of the short crus of the incus. (3) Immediately behind the fenestra vestibuli is a small conical projection called the *pyramidal eminence,* the summit of which is perforated by an aperture for the tendon of the stapedius muscle. The canal in the pyramid which contains the stapedius passes downwards and backwards in front of the facial canal and frequently opens by a minute orifice at the base of the skull in front of the stylomastoid foramen ; it communicates with the facial canal by a small foramen which transmits the vessels and a twig from the facial nerve to the muscle. (4) A minute aperture called the *iter chordae posterius* is situated at the junction of the posterior and lateral walls and on a level with the upper end of the manubrium of the malleus ; it gives entrance to the chorda tympani nerve and a branch of the stylomastoid artery.

The **lateral** or **membranous wall** is formed chiefly by the tympanic membrane and the grooved ring of bone, the tympanic sulcus, to which it is fixed. This bony ring is deficient above, where it presents a notch called the *notch of Rivinus.* In front of this ring and on a level with the upper border of the tympanic membrane is the medial end of the *petrotympanic fissure* (Glaserian fissure) ; it transmits the tympanic branch of the internal maxillary artery and lodges the anterior process and anterior ligament of the malleus. Close to the medial end of the fissure is the *iter chordae anterius* (canal of Huguier) through which the chorda tympani nerve leaves the tympanic cavity.

The **medial** or **labyrinthic wall** is formed by the lateral wall of the internal ear. It is irregular and presents the following parts : (1) In front is a rounded eminence called the *promontory* and is caused by the first turn of the cochlea ; its surface presents furrows for the nerves of the tympanic plexus ; it is often joined to the pyramidal eminence by a thin plate of bone. (2) Above and behind the promontory is situated an oval opening called the *fenestra vestibuli* (fenestra ovalis), with the long axis directed anteroposteriorly; it leads into the vestibule of the internal ear and in the recent state is closed by the base of the stapes surrounded by the ligamentum annulare baseos stapedis. (3) An opening called the *fenestra cochleae* (fenestra rotunda) is situated in a funnel shaped depression below and behind the promontory; it opens into the scala tympani of the cochlea and in the recent state is closed by the *secondary tympanic membrane*. This membrane is bent angularly along a line joining its antero-inferior two-thirds with the postero-superior one-third; it consists of three layers—an outer, continuous with the mucous lining of the tympanic cavity; an intermediate fibrous layer; and an inner, continuous with the lining membrane of the internal ear. (4) The *eminence of the facial canal* is situated above the fenestra vestibuli and indicates the position of the upper part of the facial canal (aqueductus Fallopii) in which the facial nerve lies; this canal extends backwards along the medial wall just above the fenestra vestibuli and then bending downwards along the posterior wall ends externally at the base of the skull in the stylomastoid foramen. (5) A small depression, the *sinus tympani*, is situated below the pyramid and between the fenestra vestibuli and fenestra cochlea and indicates the position of the ampullated end of the posterior semicircular canal.

The **tympanic antrum** (mastoid antrum) is a large air-cavity in the mastoid portion of the temporal bone. It communicates in front with the epitympanic recess, and below and behind, with the mastoid air cells. Its *roof* is formed by the tegmen tympani; its *floor* and *medial wall*, by the petrous and mastoid portions of the temporal bone; its *lateral wall*, by the squama of the temporal bone below the supramastoid crest.

The **membrana tympani** (Figs. 301, 302) is a thin oval membrane forming the medial boundary of the external acoustic meatus and is placed obliquely from above downwards and forwards so as to form an acute angle with the floor of the canal. Its lateral surface is concave; its medial surface is convex, and the point of its greatest convexity is called the *umbo*. The manubrium of the malleus descends upon the medial surface of the membrane and its tip lies opposite the umbo. The circumference of the membrane is fixed to the *sulcus tympanicus* except at the upper part where a gap exists in the sulcus called the *incisura tympanica* (notch of Rivinus). From the anterior and posterior ends of this notch two thickened folds, called the *anterior* and *posterior malleolar folds*, converge to the lateral process of the malleus projecting a little below the notch. The triangular piece of the membrana tympani included between the anterior and posterior malleolar folds and the incisura tympanica is loose and hence called the *pars flaccida*; the greater portion of the membrane is tense and is called the *pars tensa*.

The *arteries* of the tympanic membrane are the deep auricular branch of the internal maxillary which ramifies on its outer surface, and the anterior tympanic branch of the internal maxillary artery and the stylomastoid branch of the posterior auricular artery which ramify on the internal surface of the membrane. The *nerve supply* is derived from the tympanic branch of the glossopharyngeal, the auricular branch of the vagus, and the auriculotemporal branch of the mandibular nerve.

The **auditory tube** (Eustachian tube) establishes communication between the tympanic cavity and the nasal part of the pharynx, and transmits air to the former in order to maintain an equal pressure on both sides of the tympanic membrane. Its *tympanic orifice* opens into the anterior part of the tympanic cavity and its *pharyngeal orifice* opens on the lateral wall of the nasopharynx. It is about an inch and a half in length and is directed forwards, inwards and slightly downwards. Its lateral third is bony and its medial two-thirds is formed partly by cartilage and partly by fibrous tissue.

The *osseous portion* about half an inch long begins in the anterior wall of the tympanic cavity below the semicanalis musculus tensor tympani and separated from it by the septum canalis musculotubarii and ends in the angle between the petrous and squamous parts of the temporal bone ; medial to it is the carotid canal. The lumen of the tube is widest at the pharyngeal orifice and narrowest at the junction of the bony and cartilaginous portions forming the *isthmus* ; from the isthmus the lumen gradually increases to the tympanic orifice.

The *cartilaginous portion*, about an inch long, lies in the groove (sulcus tubæ auditivæ) between the great wing of the sphenoid and the petrous part of the temporal bone. It is formed by a triangular plate of cartilage, the apex of which is attached to the medial end of the osseous portion, while the base is free and forms a projection above and behind the pharyngeal orifice. This plate of fibrocartilage is bent on itself in such a way that the medial and upper walls are formed by it leaving a gap in the lateral and lower walls which is filled by fibrous tissue. The pharyngeal orifice is triangular in shape and lies on a level with the posterior end of the inferior nasal concha ; it is bounded above and behind by a prominent projection, the *torus tubarius* or *cushion*, produced by the base of the cartilage, which lies here against the mucous membrane.

The tube is lined with mucous membrane continuous with that of the tympanic cavity behind and the nasopharynx in front. In the osseous portion it is thin, whereas in the cartilaginous portion it is thicker and contain numerous mucous glands ; near the pharyngeal orifice, there is a considerable amount of lymphoid tissue, called the *tube-tonsil*. The tube is opened during deglutition by the dilatator tubæ and the salpingo pharyngeus muscles. The *dilatator tubæ* arises from the lateral margin of the cartilage and descends to join the tensor veli palatini and during contraction draws the lateral margin forwards and lateralwards. The *arteries* supplying the auditory tube are branches from the ascending pharyngeal, middle meningeal, and artery of the pterygoid canal; the *nerves* are derived from the tympanic plexus and the pharyngeal branch of the spenopalatine ganglion.

### The Auditory Ossicles (Fig. 303)

The tympanum contains three small bones called the auditory ossicles. They are arranged in the form of a chain and connect the lateral with the medial wall of the tympanic cavity. They are named from without inwards, the malleus, incus, and stapes. The malleus is attached to the medial side of the tympanic membrane, the stapes is fixed within the circumference of the fenestra vestibuli, and the incus is interposed between the two.

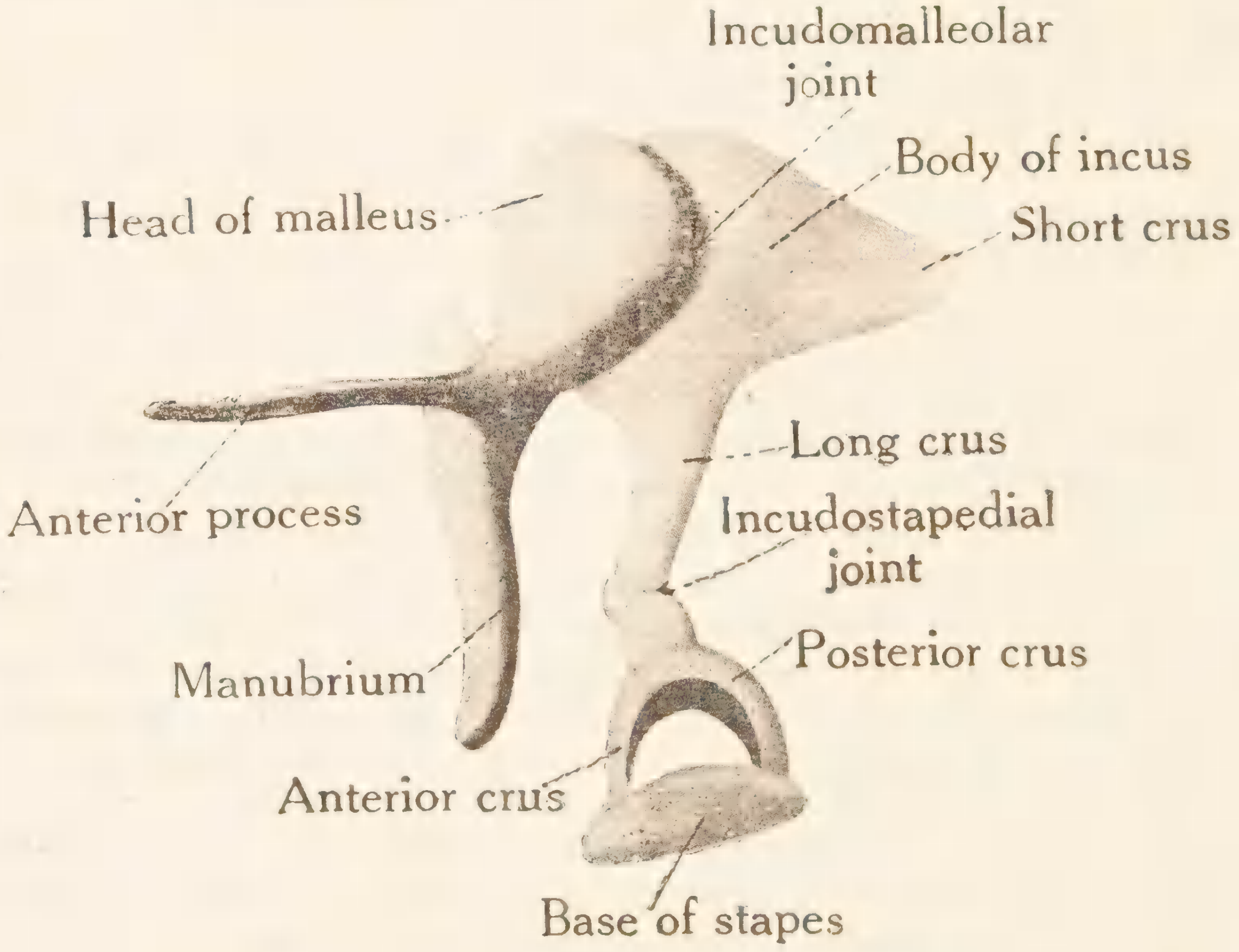


Fig 303.—The auditory ossicles.

The **malleus**, the largest of the three, resembles a hammer and consists of a head, a neck, and three processes, called the manubrium, the anterior and lateral processes. The *head* is round, smooth and convex above and in front; it projects into the epitympanic recess. Posteriorly it presents an elliptical facet, constricted in the middle, for articulation with the body of the incus. Opposite the constriction, the lower edge of the facet is prolonged as a process called the *spur* or *cogtooth* of the malleus. The *neck* is the constricted portion below the head. The *manubrium* projects downwards, backwards and medialwards.

It is fixed by its periosteum to the tympanic membrane. The tensor tympani is inserted into a projection on its medial surface near the upper end. The *anterior process* (processus gracilis) projects forwards from below the neck and is attached to the petrotympanic fissure by the anterior ligament. The *lateral process* (processus brevis) projects lateralwards and is attached to the upper part of the tympanic membrane by a layer of cartilage and to the ends of the notch of Rivinus by the anterior and posterior malleolar folds.

The **incus** resembles an anvil and consists of a body and two crura. The body and the short crus are situated in the epitympanic recess. The *body* presents anteriorly a saddle shaped facet for articulation with a similar facet on the posterior surface of the head of the malleus. The *short crus* passes horizontally backwards ; its apex is covered with cartilage and is received into the fossa incudis in the posteroinferior part of the epitympanic recess. The *long crus* descends vertically downwards into the tympanic cavity and lies parallel to, behind and medial to the manubrium of the malleus. Its lower end is bent medialwards and terminates in a rounded knob like process, called the *lenticular process*, which articulates medially with the head of the stapes.

The **stapes** resembles a stirrup and presents a head, neck, two crura, and a base. The *head* is directed laterally and presents a concave facet for articulation with the lenticular process of the incus. The *neck* is the constricted part between the head and the crura ; to its posterior surface is inserted the stapedius muscle. Of the two *crura* the anterior is shorter and less curved than the posterior. The *base* is an oval plate of bone which connects the crura and is received in the fenestra vestibuli, to the margin of which it is attached by the annular ligament. The upper margin of the base is convex and the lower almost straight.

**Ligaments of the auditory ossicles.**—There are two *articular capsules* ; one surrounds the articulation between the head of the malleus and the body of the incus ; the other surrounds the articulation between the head of the stapes and the lenticular process of the incus. The malleus is connected with the wall of the tympanic cavity by three ligaments. (1) The *anterior ligament of the malleus* connects its anterior process to the petrotympanic fissure. (2) The *lateral ligament of the malleus* connects its lateral process to the incisura tympanica. (3) The *superior ligament of the malleus* connects the head of the malleus to the roof of the tympanum. The incus is connected to the tympanic wall by the *ligament of the incus* which fixes its short crus to the posterior wall of the tympanic cavity. The *annular ligament of the stapes* connects the margin of the base of the stapes to the circumference of the fenestra vestibuli.

**Movements of the ossicles.**—The manubrium of the malleus follows all the movements of the tympanic membrane. The malleus and incus move together around an axis passing through the short crus of the incus and the anterior ligament of the malleus. When the tympanic membrane moves inwards the manubrium of the malleus also moves inwards and with it carries the long crus of the incus inwards, which in its turn moves the base of the stapes towards the labyrinth. This motion is transmitted to the perilymph in the labyrinth and causes a lateral bulging of the secondary tympanic membrane. These movements are reversed when the tympanic membrane relaxes i.e. moves outwards.

The **muscles of the tympanic cavity** are two in number, the tensor tympani and the stapedius.

The **tensor tympani** arises from the cartilaginous portion of the auditory tube, from the adjoining part of the great wing of the sphenoidal bone and from the wall of the bony canal in which it is contained. It passes backwards and lateralwards through the canal for it above the bony part of the auditory tube. Entering the tympanic cavity its tendon turns abruptly lateralwards to be inserted into the medial aspect of the manubrium of the malleus near its root. It is supplied by a branch from the otic ganglion. It draws the manubrium inwards and thus tightens the tympanic membrane.

The **stapedius** arises from the interior of the pyramid. Its tendon emerges from an aperture on the summit of the pyramid and is inserted into the posterior aspect of the neck of the stapes. It is supplied by a branch of the facial nerve. It is the antagonistic muscle of the tensor tympani for it pulls the head of the stapes backwards and thus throws the anterior end of its base lateralwards towards the tympanic cavity.

The **nerves of the tympanic cavity** are : (1) The *chorda tympani nerve* enters the tympanic cavity through the iter chordæ posterius in the posterior wall near the upper end of the membrana tympani. Then it traverses the medial surface of the membrana tympani lying between its fibrous layer and the mucous lining at the level of the upper end of the manubrium. It issues out of the tympanic cavity through the iter chordæ anterius (canal of Huguier) at the medial end of the petrotympanic fissure.

(2) The *tympanic plexus* ramifies upon the promontory on the medial wall of the tympanic cavity. It is formed by the tympanic branch of the glossopharyngeal nerve and the superior and inferior caroticotympanic branches of the internal carotid plexus of the sympathetic. Its branches supply the mucous lining of the cavity.

The nerves supplying the muscles of the tympanic cavity have been already referred to.

The **arteries of the tympanic cavity** are :—(1) The *anterior tympanic branch* of the internal maxillary artery enters the tympanic cavity through the petrotympanic fissure and supplies the tympanic membrane ; (2) the *stylomastoid branch of the posterior auricular artery* passes through the stylomastoid foramen to enter the back part of the tympanic cavity and supplies the mastoid air cells and the tympanic antrum and forms an anastomotic circle around the tympanic membrane with the anterior tympanic artery ; (3) the *petrosal branch of the middle meningeal artery* enters through the hiatus of the facial canal ; (4) the *inferior tympanic branch of the ascending pharyngeal artery* accompanies the tympanic branch of the glossopharyngeal nerve through the inferior tympanic canaliculus ; (5) the *tympanic branch of the internal carotid artery* enters through the anterior or carotid wall of the tympanic cavity ; and (6) a *small branch of the artery of the pterygoid canal* enters through the auditory tube.

The **mucous membrane of the tympanic cavity** lines the ossicles, ligaments and muscles and is continuous with that of the pharynx through the auditory tube. It lines the medial surface of the membrana tympani and also the tympanic antrum and mastoid air sinuses.

## The Internal Ear

The **internal ear** or **labyrinth** (Figs. 304, 305, 306), consists of two parts : (1) the osseous labyrinth being a series of cavities hollowed out of the petrous portion of the temporal bone, which intercommunicate with each other and are called the vestibule, semicircular canals and cochlea ; and (2) the membranous labyrinth consisting of membranous channels contained within the osseous labyrinth ; between these two parts is a clear fluid called the *perilymph.*

The **vestibule** is the central portion of the bony labyrinth and is situated behind the cochlea and in front of the semicircular canals. It is ovoid in shape and measures about one sixth of an inch anteroposteriorly. Its *lateral wall* is directed towards the tympanic cavity ; in it is the fenestra vestibuli which is closed in the recent state by the base of the stapes. Its *medial wall* corresponds to the bottom of the internal acoustic meatus and presents in front a circular depression, the *recessus sphericus,* which lodges the saccule and is perforated by minute apertures (*macula cribrosa media*) for the passage of filaments of the acoustic nerve to the saccule. Behind this circular depression is an oblique ridge called the *crista vestibuli,* the anterior end of which is triangular and is called the *pyramid of the vestibule.* The ridge encloses below a minute depression, the *fossa cochlearis,* which presents apertures for filaments of the acoustic nerve to supply the vestibular end of the ductus cochlearis. At the back part of the medial wall is the opening of the *aquaeductus vestibuli* which leads to the posterior surface of the petrous portion of the temporal bone. It lodges a diverticulum of the membranous labyrinth called the *ductus endolymphaticus,* and transmits a small vein. On the *upper wall* or *roof* is an elliptical depression called the *recessus ellipticus,* which lodges the utricle ; it is separated from the recessus sphericus by the crista vestibuli. The pyramid of the vestibule and the recessus ellipticus present numerous apertures (*macula cribrosa superior*) ; those in the former transmit the nerves to the utricle and those in the latter the nerves to the ampullæ of the superior and lateral semicircular ducts. *Behind* the vestibule communicates with the three semicircular canals by five openings and *in front* by an oval aperture with the scala vestibuli of the cochlea.

The **bony semicircular canals** are placed above and behind the vestibule. They are three in number and named superior, posterior, and lateral. Each canal forms two thirds of a circle and presents a dilatation at one end, called the *ampulla.* They open into the vestibule by five apertures, since the medial end of the superior and the upper end of the posterior join to form a common canal. The *superior semicircular canal* is vertically placed at right angles to the long axis of the petrous portion of the temporal bone ; its position is indicated on the anterior surface of the bone by the arcuate eminence. Its lateral end is ampullated and opens into the vestibule immediately above that of the lateral semicircular canal ; its medial end joins with the upper end of the posterior semicircular canal forming the *crus commune,* which opens into the upper and medial part of the vestibule. The *posterior semicircular canal* is also vertically placed parallel to the posterior surface of the petrous portion of the temporal bone. Its upper end joins the medial end of the superior semicircular canal forming the crus commune. Its lower ampullated end opens into the lower and posterior part of the vestibule, where there are small apertures (*macula cribrosa inferior*) for the passage of nerve filaments to this ampulla. The *lateral semicircular canal* is horizontal and placed between the superior and posterior semicircular canals. It projects into the medial wall of the tympanic antrum. Its anterior end is ampullated and opens near the ampullated end of the superior semicircular canal ; its posterior end opens below the crus commune.

The **cochlea** resembles the shell of a snail. It is conical in shape and situated in front of the vestibule. Its apex or *cupola* is directed forwards and lateralwards. Its *base* is directed backwards and medialwards towards the bottom of the internal acoustic meatus and is perforated by several minute apertures for the passage of filaments of the cochlear nerve. It consists of a canal wound spirally for two turns and a half around a central pillar called the *modiolus.* This canal is partially subdivided into two passages by a thin lamina of bone, termed the *lamina spiralis ossea,* which projects from the modiolus and follows the turns of the canal. The upper passage is called the *scala vestibuli* and the lower one, the *scala tympani.* The basilar membrane, which in the recent state extends from the free border of the osseous lamina to the outer wall of the bony cochlea completes the subdivision. The lamina spiralis ends above in a hook like process called the *hamulus lamina spiralis* which bounds an opening at the cupola, called the *helicotrema* ; through this opening the scala vestibuli and scala tympani communicate with each other. The *modiolus* is the central pillar of the cochlea. It is conical in shape and rapidly diminishes from base to apex.

Its base lies at the bottom of the internal acoustic meatus and exhibits (1) the tractus spiralis foraminosus which transmits the nerves for the basal and central coils of the cochlea, and (2) the foramen centrale which transmits the nerves for its apical coil. The foramina in the tractus spinalis foraminosus pass through the modiolus at first parallel to its long axis and gradually bending outwards reach the attached margin of the osseous spiral lamina where expanding they form a spiral canal called the *spiral canal of the modiolus* which lodges the spiral ganglion (ganglion of Corti).

### The Membranous Labyrinth

The membranous labyrinth is situated within the bony labyrinth and does not completely fill the latter ; the space between the two is known as the *perilymphatic space* and contains *perilymph.* The membranous labyrinth is filled with fluid called *endolymph* and its walls contain the ramifications of the branches of the acoustic nerve ; it consists of : (1) the utricle and the saccule contained within the vestibule, (2) the three semicircular ducts contained within the semicircular canals, and (3) the ductus cochlearis contained within the bony cochlea.

The **utricle** is larger than the saccule and is lodged in the posterosuperior part of the vestibule. Its highest part occupies the recessus ellipticus. The floor and anterior wall of this portion are thickened to form the *macula acustica utriculi,* to which the utricular fibres of the acoustic nerve are distributed through the foramina in the pyramid of the vestibule. The crus commune, the posterior end of the lateral semicircular duct and the ampulla of the posterior duct open into the medial part of the utricle ; the ampullæ of the superior and lateral semicircular ducts open into the lateral part of the utricle. From the medial side of the utricle a small canal, the *ductus utriculosaccularis* joins the ductus endolymphaticus.

The **saccule** is lodged in the anteroinferior part of the vestibule occupying the recessus sphericus. It presents anteriorly an oval whitish thickening, called the *macula acustica sacculi* ; to it the saccular fibres of the acoustic nerve are distributed. Its upper end is directed upwards and backwards and is separated from the utricle by a common wall. From its lower part a short canal, the *canalis reuniens* of Hensen, gradually widens downwards to join the vestibular end of the ductus cochlearis. From the posterior part of the saccule, a small channel, the *ductus endolymphaticus,* is given off and is joined by the ductus utriculosaccularis. The •ductus endolymphaticus then enters and traverses the aquæductus vestibuli to end under the dura mater on the posterior surface of the petrous part of the temporal bone in a blind pouch called the *saccus endolymphaticus.*

The **semicircular ducts** correspond exactly in contour to the bony semicircular canals within which they are contained. The convex wall of each is attached to the periosteal lining of the bony canal, while the concave wall is separated from the canal by perilymph. In the ampullated end of each duct the wall is thickened and projects into the cavity as a transverse elevation, called the *septum transversum*, the most prominent part of which is called the *crista ampullaris.*

The **ductus cochlearis** or **scala media** is a spirally arranged canal enclosed in the bony cochlea. Its lower end occupies the recessus cochlearis of the vestibule and communicates with the saccule through the ductus reuniens; its upper end is called the *lagena* and is fixed to the cupula of the cochlea and bounds the helicotrema. It has been already stated that the basilar membrane extends from the free border of the osseous spiral lamina to the lateral wall of the cochlea. Another but more delicate membrane, called the *vestibular membrane* (membrane of Reissner) extends from the thickened periosteum covering the upper surface of the osseous spiral lamina to the lateral wall of the cochlea where it is attached at some distance from the attchment of the basilar membrane. In this way a canal is enclosed between the scala vestibuli above, and the scala tympani and the basilar membrane below: this canal is called the *ductus cochlearis.*

The ductus cochlearis is triangular on transverse section and presents a roof, an outer wall, and a floor. The *roof* is formed by the vestibular membrane. The *outer wall* consists of the periosteal lining of the bony cochlea which is here thickened to form the *ligamentum spirale cochleæ.* Below the ligament is projected inwards as a triangular crest, the *crista basilaris* to which the outer margin of the basilar membrane is attached. Just above the crista basilaris is a concavity called the *sulcus spiralis externus.* The periosteum in the upper part of the ligamentum spirale contains numerous blood vessels and is hence called *stria vascularis.* The *floor* is formed by the periosteum covering that portion of the osseous spiral lamina, which lies to the outer side of the attachment of the vestibular membrane, and by the basilar membrane, which stretches from the spiral lamina to the crista basilaris. The osseous spiral lamina consists of two thin laminæ of bone: between the laminæ are canals for the branches of the cochlear nerve. The periosteum on the upper plate is thick and forms the *limbus laminae spiralis,* the outer border of which presents a concave sulcus, the *sulcus spiralis internus*; this sulcus is bounded by an upper or vestibular and a lower or tympanic lip. The lower lip presents numerous apertures for the branches of the cochlear nerve. The upper surface of the vestibular lip presents a series of furrows and elevations crossing each other at right angles and at the free margin of the lip form a row of tooth like structures called the *auditory teeth* of Huschke.

The **basilar membrane** extends from the osseous spiral lamina to the crista basilaris and separates the scala media from the scala tympani. Its inner part is thin and supports the spiral organ of Corti; it is called the *zona arcuata.* Its thicker outer part is called *zona pectinata.*

The **spiral organ of Corti** is placed on the zona arcuata of the basilar membrane and consists of the following six structures :—

(1) **Rods of Corti**—These form two rows, inner and outer, of pillar like structures. Each rod has a base or foot plate, an elongated part or body, and an upper end or head. The bases rest on the basilar membrane, those of the inner row at some distance from those of the outer. The body inclines towards each other and the heads come in contact above. Thus a triangular tunnel, the *tunnel of corti,* is enclosed between the two rows of rods and the basilar membrane ; this tunnel increases in height and width as it passes towards the apex of the cochlea. The *inner rods,* 5000 to 6000 in number, are shorter than the outer and incline upwards and outwards. The head of each resembles the proximal end of the ulna, presenting a deep concavity in which rests the convex head of the outer row of rods ; the part of the head overhanging the concavity is called the *headplate* and overlaps the head of the outer rod. The *outer rods* are about 4000 in number and are longer, more oblique and inclined towards the basilar membrane. The head of each is convex medially to fit the concavity on the head of the inner rod and is prolonged laterally as a thin plate, the *phalangeal process,* which forms the reticular lamina.

(2) **Hair cells.**—These also form two sets, inner and outer. The *inner hair cells,* about 3500 in number, lie on the medial side of the inner rods and form a single row. Their free extremities lie close to the heads of the rods and are provided with hair like filaments. Their deep ends reach about half way down the rods and lie in contact with the arborizations of the cochlear nerve. Internal to the inner hair cells are two or three rows of columnar cells which are continuous with the columnar cells of the sulcus spiralis internus. The *outer hair cells* about 12000 in number are arranged in three rows in the basal coil and four rows in the apical two coils.

(3) **Deiter's supporting cells.**—These alternate with the rows of outer hair cells. Their lower ends are expanded on the basilar membrane ; their upper ends are tapered. Each cell contains a thread like structure called the *supporting fibre,* which is attached below to the basilar membrane and expands above to form one of the phalanges of the reticular membrane.

(4) The **cells of Hensen** consist of six rows arranged external to Deiter's cells and form a well marked elevation on the floor of the ductus cochlearis. Their deep ends are narrow and are attached to the basilar membrane, while their free ends are expanded. External to these cells are the columnar *cells of Claudius.* Between the outer rods of Corti and outer hair cells is the *space of Nuel* which extends laterally as far as Hensen's cells and communicates with the Corti's tunnel.

(5) The **reticular lamina** extends from the heads of the outer rods as far as Hensen's cells. It consists of two or three rows of structures called *phalanges.* The innermost row is formed by the phalangeal processes of the heads of the outer

rods of Corti; the succeeding rows are the expanded upper ends of Deiter's supporting cells. The free ends of the outer hair cells lodge in circular apertures between the constricted middle portions of the phalanges.

(6) The **membrana tectoria** overhangs the sulcus spiralis internus and the spiral organ of Corti. Medially it is attached to the limbus lamina spiralis near the lower edge of the membrana vestibularis; laterally it reaches as far as the outer row of hair cells.

The **acoustic nerve** enters the internal acoustic meatus with the facial nerve. At the bottom of the meatus it divides into two branches, an anterior or cochlear and a posterior or vestibular.

The **cochlear nerve** gives off a vestibular branch which passes through the foramina in the fossa cochlearis to supply the vestibular end of the ductus cochlearis. Practically the whole of the nerve is distributed to the hair cells of the spiral organ of Corti. The branches for the basal and middle coils enter the foramina in the tractus spiralis foraminosus; those for the apical coil run in the canalis centralis of the modiolus. The nerve fibres traverse the canals of the modiolus and then radiate outwards between the lamellæ of the osseous spiral lamina. A ganglion, named the *spiral ganglion of the cochlea* (ganglion of Corti) is situated in the spiral canal of the modiolus near the attached margin of the lamina. The spiral ganglion is contained in the spiral canal of the modiolus and consists of bipolar nerve cells. The fibres of the nerve arise from the cells of this ganglion. From the spiral ganglion the nerve fibres extend outwards, emerge from the foramina in the tympanic lip and enter the basilar membrane. Some of the fibres end around the base of the inner hair cells; others pass between the inner and outer rows of rods and across Corti's tunnel to end around the base of the outer hair cells. The hair cells in the apical coil are not so abundantly supplied with nerve filaments as those in the basal and middle coils.

The **vestibular nerve** is distributed to the utricle, saccule, and the ampullæ of the semicircular ducts. In the internal acoustic meatus it presents an enlargement called the *vestibular ganglion* (ganglion of Scarpa); it then divides into three branches, a posterior, an inferior, and a superior. Occasionally this division into branches takes place before the nerve becomes enlarged and then the ganglion splits into three parts, one for each nerve. The posterior branch passes through the foramen singulare, its filaments being finally distributed to the crista ampullaris of the posterior semicircular duct. The filaments from the inferior branch pass through foramina in the area vestibularis inferior to end in the macula of the saccule. The filaments from the superior branch pass through foramina in the area vestibularis superior to supply the macula of the utricle and the cristæ ampullares of the superior and lateral semicircular ducts.

The **arteries of the internal ear** are two in number. (1) The *internal auditory artery* is a branch of the basilar artery and divides at the deep end of the internal acoustic meatus into two branches, vestibular and cochlear. The *vestibular branch* supplies the utricle, saccule and semicircular ducts. The *cochlear branch* divides into numerous twigs and supplies the cochlea. (2) The *stylomastoid artery* is a branch of the posterior auricular artery and supplies twigs to the cochlea.

### The Peripheral Terminations of the Nerves of General Sensations

The nerves associated with general sensations may terminate (1) as free nerve-endings or (2) in special end-organs. *Free nerve endings* are seen mainly in the epithelium covering the skin or mucous membranes. The nerve fibres lose their medullary sheaths in the subepithelial connective tissue and are continued as naked axis cylinders to ramify in the epithelial cells where they terminate in minute knobs. The *special end organs* vary in form and size ; in each however the termination of the axis cylinder is enclosed within a capsule of connective tissue. The following are some of the varieties of special end organs . (1) The *end bulbs of Krause* are oval bodies seen in the mucous membrane of the lips, conjunctiva and skin of glans penis and glans clitoridis. (2) The *corpuscles of Pacini* are oval bodies seen in the parietal peritoneum, the cutaneous nerves of the neck, hand and foot, and nerves of the joints. (3) The *corpuscles of Golgi and Mazzoni* are seen in the pulp of the fingers and some parts of the skin. (4) The *tactile corpuscles of Wagner and Meissner* are seen in the skin of the lips, palpebral conjunctiva and the corium of hand, forearm and foot. (5) The *neuromuscular spindles* have an extensive distribution throughout the voluntary muscles of the body.

### The Common Integument

The covering which envelops the whole external surface of the body is called the **common integument** or **skin.** It is broken in certain situations where it merges with mucous membranes. It contains the peripheral terminations of the sensory nerves and serves as an organ of protection to the underlying tissues. It is also the chief organ for the regulation of the body temperature. It is elastic and its thickness varies in different regions of the body. The colour varies greatly ; it may be white, yellow, black, according to the colour the races of mankind have been divided. The colour is due partly to pigment and partly to the blood within the cutaneous vessels. The skin presents apertures of the ducts of sebaceous and sudoriferous glands and of hair follicles. The skin consists of two layers : (1) the superficial layer or *epidermis* or *cuticle* which is derived from the embryonic ectoderm ; and (2) the deep layer or *corium* or *cutis vera* which is derived from the embryonic mesoderm. The *arteries* of the skin ramify and anastomose freely in the corium where they supply the glands and hair follicles. The *nerves* of the skin vary in number in different parts of the body and are present in greater proportion in those parts which are most sensitive. The appendages of the skin are the hairs, the nails, and the sebaceous and sudoriferous glands.

# SURFACE ANATOMY

## THE HEAD

**Bony landmarks.**—The *nasion* is the depressed area overlying the frontonasal suture. A little above it is the *glabella* which connects the superciliary arches. The *supraorbital margin* is easily felt and at the junction of the medial with the intermediate one-third of the supraorbital margin is the *supraorbital notch* which, if present, can be more easily palpated from below. The *superciliary arch* is the ridge upon which the eyebrow is set and it overlies the frontal air-sinus. The *infraorbital margin* is easily felt and about ¼ inch below the centre of the infraorbital margin is the *infraorbital foramen* ; at the medial end of the infraorbital margin is a small tubercle, the *lacrimal tubercle,* which serves as a guide to the lacrimal sac. The *frontal air sinus* is indicated on the surface of the body by drawing a triangular figure, the angles of which are formed by (1) the nasion, (2) a point situated at the junction of the lateral with the intermediate one-third of the supraorbital margin, and (3) a point in the middle line of the body 1¼ inch above the nasion. The *maxillary air sinus* is indicated on the surface of the body by drawing a triangular figure, the angles of which are formed by (1) the centre of the prominence of the cheek immediately below the lateral margin of the orbit, (2) the skin over the alveolar process of the maxilla opposite the second upper molar tooth, and (3) the medial extremity of the infraorbital margin. The *zygomatic process* of the frontal bone can be palpated at the superior and lateral portion of the orbit. The *zygomatic arch* lies on the same level as the inferior margin of the orbit—its anterior end is continued into the zygomatic bone and its posterior end lies a little above the level of the tragus. The *superior temporal line* demarcates the scalp proper from the superior limit of the temporal region ; it begins from the zygomatic process of the frontal bone, runs posteriorly along the side of the head and then inferiorly behind the ear and ends in the posterior root of the zygomatic arch ; it presents a general convexity upwards ; its anterior portion is distinct and in the rest of its extent it is less marked but can be felt. The *external occipital protuberance* (inion) is easily felt and the *superior nuchal line* runs from it as an inconspicuous ridge laterally towards the mastoid process. The *mastoid process* can be easily palpated behind the lower part of the ear. The auricula should be drawn forwards and then the position of the *tympanic antrum* (*mastoid antrum*) is indicated on the surface by the suprametal triangle of Macewen which is bounded above by the posterior root of the zygomatic arch, in front and below by the upper margin of the orifice of the bony acoustic meatus, and behind by a vertical line drawn from the posterior border of the same orifice. Almost the whole of the *mandible* can be palpated and its condyle lies in front of the tragus and below the zygomatic arch. The *temporomandibular joint* lies in front of the external acoustic meatus and below the posterior end of the zygomatic arch. The *bregma* is the junction of the coronal and sagittal sutures and lies close to the middle line; the *lambda* is the junction of the lambdoid and sagittal sutures and also lies close to the middle line. In the infant the anterior fonticulus is situated at the bregma and the posterior fonticulus at the lambda. The *sagittal suture* extends from the bregma to the lambda and the *lambdoid suture* from the lambda to the mastoid process. The *squamous suture* extends from the pterion to the mastoid process. The *pterion* corresponds to the meeting point of four bones viz. frontal, parietal, sphenoidal and temporal, and lies about 1½ inches posterior to the zygomatic process of the frontal bone and also 1½ inches above the zygomatic arch. The other bony landmarks utilised for surface markings are described on pp. 80-81. The line drawn through the inferior margin of the orbit and the auricular point is called *Reid's base-line.*

**Arteries.**—The surface marking of the *external maxillary artery* is important an account of: (1) a portion of the artery lies lateral to the palatine tonsil, the superior constrictor muscle of the pharynx only intervenes which should be borne in mind during the operation of removal of tonsil; (2) its pulsation may be felt during anæsthesia and also it may be compressed for controlling hæmorrhage—where the artery crosses the mandible; (3) the angular artery lies medial to the lacrimal sac—hence when an incision is required into the sac, it should be made lateral to the artery. The course of the artery on the face is indicated by a line drawn from the lower border of the mandible at the anterior margin of the masseter; from this point the line is continued superiorly and anteriorly to a point about ½ inch lateral to the angle of the mouth and thence to the ala of the nose and finally upwards to the medial commissure of the eye immediately medial to the lacrimal sac. The pulsation of the *occipital artery* may be felt about 1½ inches lateral to the external occipital protuberance and that of the *posterior auricular artery* in the space between the mastoid process and auricula. The *middle meningeal artery* is of great surgical importance, since it is frequently ruptured in fractures of the skull. The main trunk reaches the side wall of the skull about the midpoint of the zygoma; it bifurcates into an anterior and a posterior branch either at that point or about ½ inch above the midpoint of the zygoma. The anterior branch runs to the pterion and then passes superiorly and posteriorly towards the midpoint of a line drawn from the nasion to the external occipital protuberance. The *posterior branch* runs horizontally backwards towards the mastoid angle of the parietal bone.

**Venous sinuses.**—The *superior sagittal sinus* occupies the median plane of the vertex from the nasion to the external occipital protuberance. The *transverse sinus* is indicated on the surface by drawing two lines: (1) from the inion to a point about 1 inch behind the auricular point—this portion of the sinus has a slight upward convexity and the highest part of the sinus lies a finger's breadth above the middle of a line drawn from the inion to the middle of the external acoustic meatus; (2) from the auricular point to the tip of the mastoid process—the upper two thirds of this portion of the sinus represents the sigmoid part of the sinus, and the commencement of this descending portion of the sinus is intimately related to the mastoid antrum and air cells.

**Nerves.**—The *supraorbital* and *infraorbital nerves* emerge from the corresponding foramina. The *facial nerve* after emerging from the stylomastoid foramen enters the substance of the parotid gland; the nerve crosses the posterior border of the ramus of the mandible at the level of the lower border of the tragus.

The **palatine tonsil** is about 1 inch in length, ½ inch in breadth, and its long axis is vertical. Its position corresponds to a point about ½ inch above and in front of the angle of the mandible. The internal carotid artery lies about 1 inch behind and to the lateral side of the tonsil. When serious hæmorrhage occurs after operation, it usually comes from one of the tonsillar branches.

The **parotid gland** occupies a region which would be thus mapped out: above by the zygoma; below by a line from the tip of the mastoid process to the angle of the mandible, and a small posterior portion of the lower border of the mandible; in front by a vertical line from the inferior border of the mandible to the zygoma—this line overlaps the posterior part of the masseter to a variable degree; behind by the external acoustic meatus and the mastoid process. The **parotid duct** is indicated on the surface by the middle third of a line drawn across the face from the lobule of the ear to midway between the ala of the nose and the red margin of the upper lip—the duct ends opposite the second upper molar tooth.

The **lacrimal gland** is situated behind the lateral part of the supraorbital margin and the gland can not be felt unless enlarged. By drawing the lower lid downwards the **punctum lacrimale** is seen near the medial palpebral commissure but the corresponding orifice in the upper lid is situated a little nearer the commissure. The **medial palpebral ligament** can be felt at the medial corner of the eye by drawing the lids laterally—the band passes transversely to be attached to the frontal process of the maxilla. This ligament serves as a guide to the position of the **lacrimal sac**—it crosses the sac a little above its centre. The **nasolacrimal duct** is the continuation of the inferior end of the lacrimal sac—the direction of the duct is indicated on the surface by a line about ½ inch in length drawn from the inferior end of the sac to the first upper molar tooth.

**Brain.**—The *longitudinal fissure* corresponds to a line drawn from the nasion to the inion along the median line of the scalp. The *posterior ramus of the lateral cerebral fissure* is indicated on the surface by a line drawn posteriorly and slightly superiorly from the pterion for about 3 inches. The *central sulcus* may be marked out in the following way : the sagittal line from glabella to external occipital protuberance is bisected and a point ½ inch behind the centre is taken—from this point a line drawn downwards and forwards 3¾ in. long and ending 2 in. above the preauricular point, at an angle of 67½° with the sagittal line, corresponds to the central sulcus. The *anterior central gyrus* is represented on the surface by a strip parallel to the line representing the central sulcus ; this strip is ½ inch in width anteroposteriorly lying in front of the central sulcus—the cortical motor area is situated in this gyrus. The *posterior central gyrus* lies behind the central sulcus and is indicated on the surface by following the above method—the cortical area for common sensation is situated in this gyrus.

## THE NECK

**Bones.**—The *superior border of the sternum* can be easily felt. The whole of the *clavicle* is practically subcutaneous and its both extremities may be palpated. In the median line of the neck the *hyoid bone* is best palpated when the head is thrown backwards ; its *greater cornu* can be felt extending laterally and posteriorly from the body of the bone. In the furrow which runs down the middle line of the back of the neck from the external occipital protuberance, the *spine of the epistropheus* can be felt as the first bony point below that protuberance, in as much as the atlas has no spine but possesses a posterior tubercle. In the same furrow the *spines of the third, fourth, fifth* and *sixth cervical vertebrae* may be felt with great difficulty but the *spine of the seventh cervical* being very prominent is readily palpated. The *transverse process of the atlas* may be felt on palpating between the angle of the jaw and the mastoid process. The *anterior tubercle of the transverse process of the sixth cervical vertebra* or Chassaignac's tubercle may not be felt but it lies at the level of the cricoid cartilage and if required the common carotid artery can be compressed against this tubercle. The *supraclavicular fossa* is the space immediately above the middle of the clavicle and corresponds to the interval between the posterior border of the sternocleidomastoideus and the anterior border of the trapezius.

**Joints.**—The *sternoclavicular joint* lies inferomedial to the sternal end of the clavicle. The *acromioclavicular joint* lies lateral to the acromial end of the clavicle and its position is indicated on the surface by an anteroposterior line drawn about 1½ in. medial to the lateral border of the acromion.

**Muscles.**—The *sternocleidomastoideus* is an important landmark and may be made prominent by turning the head to the opposite side. It is indicated on the surface by two parallel lines, 1½ in. apart : (1) from the lateral extremity of the superior muchal line to the sternal end of the clavicle, (2) from the mastoid process to to the lateral part of the superior end of the sternum. The anterior border of the *trapezius* is indicated on the surface by drawing a line from the junction of the medial and middle thirds of the superior nuchal line to the junction of the lateral and middle-thirds of the clavicle. The anterior belly of the *digastricus* is marked out by drawing a line from the body of the hyoid bone about 1 in. from the middle line to a point just lateral to the symphysis of the mandible ; its posterior belly is indicated by a line drawn from the tip of the mastoid process to the body of the hyoid bone, about 1 in. from the middle line. The anterior belly of the *omohyoideus* is indicated by drawing a line from the body of the hyoid bone ½ in. from the middle line to the sternocleidomastoideus, at the level of the cricoid cartilage ; its posterior belly is marked out by prolonging this line downwards but more horizontally to the acromial end of the clavicle.

**Arteries.**—The *carotid sheath* is marked out by drawing a line from the superior end of the sternoclavicular articulation to a point midway between the angle of the mandible and the tip of the the mastoid process—(1) up to the level of the superior border of the thyreoid cartilage the line lies over the *common carotid artery* ; (2) above the level of the superior border of the thyreoid cartilage the line represents the *external carotid artery* and the *internal carotid artery* ; (3) the whole of this line lies over the *internal jugular vein, vagus nerve* and *cervical sympathetic trunk*. If the whole of this single line is utilised for marking out the five structures mentioned above, the position of the line should be slightly modified according to the relation of the particular structure : thus the carotid arteries lie medial to the internal jugular vein, or the external carotid lies medial to the internal carotid artery. Four branches of the external carotid artery are related to the tip of the greater cornu of the hyoid bone : the *superior thyreoid* arises just below it ; the *lingual* issues on a level with it ; the *external maxillary* and *occipital* arise a little above and behind it. The *right subclavian artery* or the *cervical portion of the left subclavian artery* is indicated on the surface by drawing a curved line, convex upwards, from the sternoclavicular joint to the middle of the clavicle—the higest point of the curve is about ¾ in. above the clavicle.

**Veins.**—The surface marking of the *internal jugular vein* has been described. The *common facial vein* joins it at the level of the hyoid bone. The line of the *anterior jugular vein* begins from just below the chin, runs downwards about ½ in. from the middle line to the sternal end of the clavicle and then turns laterally to the inferior end of the external jugular vein. The *external jugular vein* is indicated by line drawn from the angle of the mandible to the middle of the clavicle.

**Nerves.**—The lines of the *vagus nerve* in the neck and the *cervical sympathetic trunk* have been described. The *accessory nerve* is indicated on the surface by drawing a line from a point midway between the tip of the mastoid process and the angle of the mandible to a point, a little above the middle of the posterior border of the sternocleidomastoideus, and thence across the posterior triangle to the junction of the middle and inferior thirds of the anterior border of the trapezius—beneath this muscle it passes at the level of the seventh cervical spine. The *hypoglossal nerve* is deeply placed and is overlapped by the internal jugular vein and the lower border of the posterior belly of the digastricus. The *great auricular, lesser occipital, cervical cutaneous* and *supraclavicular nerves* emerge from a point about the middle of the posterior border of the sternocleidomastoideus; these nerves are mapped out on the surface by drawing lines from this point along their courses. The *phrenic nerve* begins deeply about the level of the middle of the thyreoid cartilage, descends almost vertically towards the inner end of the clavicle and is overlapped by the lateral margin of the internal jugular vein. The *cervical plexus* lies deep to the posterior border of the upper half of the sternocleidomastoideus. The level of the upper border of the *brachial plexus* would be given by a line drawn from the side of the cricoid cartilage to the centre of the clavicle.

**Larynx** and **trachea.**—About 1 in. below the hyoid bone is the *pomum Adami* which is more prominent in the male than in the female. On either side of the pomum Adami are the *laminæ of the thyreoid cartilage*; the superior border of the lamina is the landmark for the bifurcation of the common carotid artery. The space between the hyoid bone and superior border of the thyreoid cartilage is occupied by the *hyothyreoid membrane.* The level of the *vocal folds* (true vocal cords) corresponds to the middle of the anterior margin of the thyreoid cartilage. When the neck is extended the *cricoid cartilage* is readily felt below the thyreoid cartilage and indicates the level of the following: (1) the sixth cervical vertebra; (2) the junction of pharynx and oesophagus; (3) the junction of larynx and trachea; (4) the crossing of the omohyoideus over the common carotid artery. Above the cricoid cartilage and between it and the thyreoid cartilage is the *cricothyreoid ligament* which is divided in the operation of laryngotomy; below the cricoid cartilage is the *trachea* which ends posterior to the sternal angle by dividing into the right and left bronchi. The second, third and fourth rings of the trachea are covered by the isthmus of the thyreoid gland and cannot be palpated. The succeeding three or four rings in the lower part of the neck may be felt in emaciated subjects.

The cervical portion of the **oesophagus** is indicated on the anterior aspect of the body by drawing a line from the inferior border of the cricoid cartilage in the middle line to the seventh left costal cartilage 1 in. from the middle line; on the posterior aspect of the body, the line of the œsophagus is from the sixth cervical spine in the middle line to a point 1 in. to the left of the tenth thoracic spine.

The normal **thyreoid gland** can not be felt. Each of its lateral lobes is indicated on the surface thus: above it extends up to the middle of the lamina of the thyreoid cartilage; below, to a point a little above the level of the clavicle; anteriorly, to a vertical line drawn at the lateral extremity of the isthmus; posteriorly to a vertical line drawn $\frac{3}{4}$ inch lateral to the vertical line for the anterior limit. Anteriorly it is moulded on the lower portions of the laminæ of the thyreoid cartilage and the upper part of the trachea while posteriorly it overlaps the carotid sheath. The *isthmus* of the thyreoid gland lies below the cricoid cartilage. The **submaxillary gland** lies in the anterior portion of the digastric triangle; its superficial portion can be palpated by directing the finger where a portion of the gland lies under cover of the body of the mandible.

## THE THORAX

**Bones.**—The *superior border of the sternum* is easily palpable between the medial ends of the two clavicles. The *manubrium, body* and *xiphoid process* are also easily felt. The *infraclavicular fossa* is the space immediately below the clavicle. The *sternal angle* (*angulus Ludovici*) is felt as a transverse ridge at the junction of the manubrium and body and is situated at the level of the second sternocostal joint—it is a landmark utilised for identifying and counting the costal cartilages and ribs. The *last two ribs* are best palpated from the back; sometimes they lie embedded in the sacrospinalis and do not project from the lateral margin of the muscle and thus can not be felt. The highest point of the *costal margin* is formed by the seventh costal cartilage and the lowest point by the tenth costal cartilage; the whole costal margin can be easily felt. The *subcostal* or *infracostal angle* is the angle formed by the right and left costal margins. The *infrasternal fossa* or *pit of stomach* is the space contained within the subcostal angle of the upper portions of the right and left costal margins. The *tip of the coracoid process of the scapula* lies deeply under cover of the anterior part of the deltoideus and is situated below the junction of the middle and lateral thirds of the clavicle. The *vertebral border* and *inferior angle of the scapula* may be palpated. The *spine of the scapula* is subcutaneous and can be palpated throughout its whole length.

**Surface lines.**—For the convenience of topographical and clinical description certain lines are drawn on the surface of the thorax. These lines are: (1) the *midsternal* or median line; (2) the *mammary* or *midclavicular line* which passes vertically downwards from the middle of a line drawn from the centre of the jugular notch to the tip of the acromion; (3) the *lateral sternal line* which passes vertically along the margin of the sternum; (4) the *parasternal line* which runs vertically midway between the mammary and lateral sternal lines; (5, 6) the *anterior* and *posterior axillary lines* which run vertically from the corresponding anterior and posterior folds of the axilla; (7) the *midaxillary line* passes vertically from the apex of the axilla; (8) the *scapular line* runs vertically from the inferior angle of the scapula.

**Pleuræ** (Fig. 159).—The *cervical pleura* is mapped out by drawing a line from the sternoclavicular joint; the line is to be continued upwards and slightly lateralwards for about 1 in. (the average height to which it rises) and then to be rounded off and finally to be sloped inferiorly and laterally so as to meet the point of junction of the medial and middle thirds of the clavicle. The *anterior border of the right pleura* is indicated on the surface by drawing a line which passes through the right sternoclavicalar joint downwards and medialwards to the midpoint of the junction of the manubrium and body of the sternum and then straight downwards along the midsternal line to the lower end of the body of the sternum or on to the xiphoid process.

The *anterior border of the left pleura* is mapped out by drawing a line which passes through the left sternoclavicular joint downwards and medialwards to the midpoint of the junction of the manubrium and body of the sternum and then straight downwards along the midsternal line to the level of the fourth costal cartilage; thereafter the line is to be continued lateralwards to the fourth left sternocostal joint and finally downwards along the left border of the sternum to the sixth left sternocostal joint.

The *inferior border of both pleurae* is indicated by drawing a curved line with a downward convexity from the lower end of the line of the anterior border of each pleura to a point about 1 in. lateral to the twelfth thoracic spine—this line crosses the eighth rib in the mammary line, the tenth rib in the midaxillary line, and the twelfth rib in the scapular line . The relation of the twelfth rib to the pleura is important; as the twelfth rib is very obliquely placed, the pleura extends below the medial extremity of this rib but falls short at the lateral extremity of the rib.

**Lungs** (Fig. 159).—The *apex of the lung* has the same surface markings as the cervical pleura. To delineate the *anterior border of the right lung* a line is drawn from the apex downwards and medialwards through the sternoclavicular joint to the midpoint of the junction of the manubrium and body of the sternum; from this point the line runs straight downwards in the midsternal line to the level of the sixth costal cartilage.

The *anterior border of the left lung* is indicated on the surface by drawing a line from the apex downwards and medialwards through the sternoclavicular joint to the midpoint of the junction of the manubrium and body of the sternum; from this point the line runs straight downwards in the midsternal line, side by side with the anterior border of the right lung, to the level of the fourth costal cartilage; from this point the line curves lateralwards and downwards along the fourth left costal cartilage to a point about 1 in. lateral to the left border of the sternum and finally downwards and medialwards to the sixth left costal cartilage.

The *inferior border of both lungs* is indicated by drawing a curved line with downward convexity from the lower extremity of the line for the anterior border, to the tenth thoracic spine—this line crosses the mammary line at the sixth rib, the midaxillary line at the eighth rib, and the scapular line at the tenth rib. The *posterior border of each lung* is delineated by drawing a line from the seventh cervical spine running downwards across the costoverteberal joints to the level of the tenth thoracic spine.

The *oblique fissure* of the lung is indicated by a line drawn downwards and forwards round the thorax from the second thoracic spine to the sixth costal cartilage. The *transverse fissure* of the right lung is marked by a line drawn lateralwards from the midsternal line opposite the fourth costal cartilage till it meets the line of the oblique fissure in the midaxillary line. The *roots of the lungs* should be marked on the back because it lies nearer the posterior than the anterior wall of the thorax ; they are placed opposite the fourth, fifth and sixth thoracic spines—this area corresponds roughly to the space between the root of the spine of the scapula and the inferior angle of the bone.

**Heart** (Fig. 159).—The extent of the heart in relation to the front of the thorax is indicated thus :—The *apex* is determined by taking a point in the left fifth intercostal space, 3½ in. to the left of the midsternal line ; from this point a line drawn to the seventh right sternocostal articulation across the junction of the xiphoid process with the body of the sternum, indicates the *lower border* of the heart. A line drawn from the seventh right sternocostal articulation to the upper border of the third right costal cartilage half an inch from the right border of the sternum, with its convexity to the right indicates the *right border* of the heart. A line drawn from the apex of the heart to the lower border of the second left costal cartilage one inch from the left border of the sternum, with its convexity to the left indicates the *left border* of the heart. A line drawn from the lower border of the second left costal cartilage one inch from the left border of the sternum to the upper border of the third right costal cartilage half an inch from the right border of the sternum, indicates the *upper border* of the heart. The area of superficial or *complete cardiac dulness* is the area on the thoracic wall overlying that portion of the anterior surface of the heart which is uncovered by lung. It is more or less triangular in outline and is indicated thus : a line is drawn from the apex of the heart to the midsternal line at the level of the fourth costal cartilage, and another from the apex to the junction of the body and xiphoid process at the midsternal line ; a third line connects the two points at the midsternal line. Latham defined this area by drawing a circle 2 in. in diameter around a point midway between the left nipple and the end of the sternum. The area of deep or *relative cardiac dulness* is the area on the thoracic wall overlying the outline of the whole heart and is partially overlaid by lung—it is thus a larger area and includes the area of superficial cardiac dulness.

The **orifices of the heart** are indicated on the surface thus :—The *pulmonary orifice* is the highest and placed at the upper limit of the third left sternocostal articulation ; the *aortic orifice* is a little lower and medial to this, being quite close to the same articulation ; the *left atrioventricular orifice* is situated below the aortic orifice and lies opposite the left fourth costal cartilage close to the left border of the sternum ; the *right atrioventricular orifice* is placed below and to the right and lies opposite the fourth right intercostal space behind the right half of the sternum.

**Arteries.**—The *ascending aorta* is indicated by a broad line extending from a point slightly to the left of the midsternal line opposite the third costal cartilage to the second right sternocostal joint. The aorta is most superficial opposite the second right costal cartilage which, for this reason, has been called the *aortic cartilage.* The *arch of the aorta* is indicated by a broad curved line extending from the point where the ascending aorta ends to a corresponding point on the left side—the curved line with its convexity directed above lies behind the lower half of the manubrium sterni and the summit of the curve reaches the middle of the manubrium. The *descending thoracic aorta* is indicated by a broad line extending from the point where the arch of the aorta ends to a point in the middle line ½ in. above the transpyloric plane. The *pulmonary artery* lies behind the left border of the sternum opposite the second interspace and the second costal cartilage—this marking indicates only the portion of the artery which runs straight upwards and is projected on the surface and not the portion of the artery which runs backwards. The *innominate artery* is indicated by a line drawn from the middle of the manubrium sterni to the right sternoclavicular joint. The *left common carotid artery* is indicated by a line drawn from a point a little to the left of the middle of the manubrium to the left sternoclavicular joint. The *internal mammary artery* descends down to the sixth intercostal space about ½ in. lateral to the side of the sternum.

**Veins.**—The *right innominate vein* descends almost vertically from the right sternoclavicular joint to terminate behind the cartilage of the first rib close to the right border of the sternum. The *left innominate vein* extends very obliquely from the left sternoclavicular joint to the point of termination of the right vein. The *superior vena cava* descends from the point of meeting of the two innominate veins vertically to the level of the third right costal cartilage ; it opens into the right atrium behind the third chondrosternal joint and this point corresponds to the centre of the root of the right lung. The *inferior vena cava* opens into the right atrium at the level of the upper border of the sixth right costal cartilage about ¾ in. from the middle line of the sternum.

## THE ABDOMEN

**Bones.**—The *crest of the ilium* and the *anterior superior iliac spine* can be easily palpated. The *posterior superior iliac spine* can be felt with some difficulty ; it lies opposite the second sacral spine and 1½ in. lateral to the middle line. About 2 in. behind the anterior superior iliac spine is felt the *tubercle* on the crest of the ilium. The highest point of the crest of the ilium lies on a level with the fourth lumbar spine. The *pubic tubercle* is easily felt only in thin subjects. In case of difficulty the tendon of origin of the adductor longus is the guide, as this tendon arises just below the pubic tubercle. The *pubic crest,* about 1 in. long, extends lateralwards from the symphysis pubis to the pubic tubercle. The *symphysis pubis* is easily palpated in the middle line at the lower end of the anterior abdominal wall.

The groove seen in the middle line from the xiphoid process to the symphysis pubis is the depression between the two recti muscles and corresponds to a longitudinal fibrous structure underneath called the *linea alba.* A little below its centre is the *umbilicus* which lies at the level of the middle of the body of the fourth lumbar vertebra. If the rectus muscle is well developed or if the muscle be made to contract a curved line is seen at the lateral margin of the muscle corresponding to the *linea semilunaris.* The *inguinal furrow* is seen as a curved linear depression which corresponds to the line of the inguinal ligament. The *subcutaneous inguinal ring* is situated about ½ in. above and lateral to the pubic tubercle—by invaginating the skin of the scrotum the finger may be passed through the ring into the canal. The *abdominal inguinal ring* is situated about ½ in. above the middle of the inguinal ligament. The *inguinal canal* is indicated by a broad line joining the markings of the two rings.

**Surface lines.**—In order to facilitate the description of the situation of the viscera it is customary with anatomists to divide the abdominal cavity into nine regions by four planes. The regions and planes have been described on p. 297.

**Stomach.**—The shape, size and position of the stomach vary under a variety of circumstances. The surface anatomy of a moderately filled stomach with the body in the supine position is described below. The *cardiac orifice* is situated opposite the seventh left costal cartilage about 1 in. from the lateral margin of the sternum and lies on a level with the tenth thoracic spine. The *pyloric orifice* lies on the transpyloric line immediately to the right of the middle line—this corresponds to a point 2 in. below the seventh right sternocostal joint and is on a level with the first lumbar vertebra. The *lesser curvature* is indicated by drawing a curved line with the convexity downwards and to the left from the point of the cardiac orifice to that of the pyloric orifice. The highest point of the *fundus* lies on a level with the left sixth costal cartilage or the fifth intercostal space in the left lateral line.

The *greater curvature* is indicated by drawing a curved line from the cardiac orifice to the highest point of the fundus and then downwards and to the left, thereafter passing medialwards to the pyloric orifice—this line crosses the left costal margin opposite the tip of the ninth costal cartilage, where the transpyloric line intersects the left lateral line. An important surface area which elicits a tympanitic note on percussion and is known as the *semilunar space of Traube* , is bounded above by the inferior border of the left lung, to the right by the inferior border of the left lobe of the liver, to the left by the anterior border of the spleen and below by the left costal margin. The portion of the stomach which lies in contract with the anterior abdominal wall is mapped out by a triangular figure —the base of the triangle is fromed by a line drawn from the tip of the tenth left costal cartilage to the tip of the ninth right costal cartilage ; the two sides of the triangle are formed by two lines drawn from the end of the eighth left costal cartilage to the two terminal points of the base.

**Intestine.**—The *duodenojejunal flexure* is situated just below the transpyloric plane about 1 in. to the left of the median plane. The *duodenum* is indicated on the surface by first marking the pyloric orifice and the duodenojejunal flexure and the remainder of its surface anatomy can then be mapped out from its general anatomy. The coils of the *jejunum* and *ileum* lie in front of the abdominal cavity ; broadly speaking, the former occupy the left lumbar, left iliac, and left half of umbilical regions ; the latter, the right lumbar, right iliac, and right half of umbilical regions and partly the hypogastric region. The *cæcum* lies in the right iliac region ; its lower margin corresponds to the centre of a line drawn from the right anterior superior iliac spine to the upper border of the symphysis pubis. The *ileocaecal valve* is indicated by a point which corresponds to the medial angle between the transtubercular and right lateral lines, and the opening of the *vermiform process* into the cæcum is situated one inch inferiorly. The *ascending colon* ascends through the right lumbar region lateral to the right lateral line. The *right colic flexure* lies in the right lower angle between the transpyloric and right lateral lines.

The *transverse colon* passes through the bordering areas of the epigastric and umbilical regions, and its lower border lies above the level of the umbilicus but it may hang down to a much lower level. The *left colic flexure* lies in the upper left angle between the transpyloric and left lateral lines. The *descending colon* descends through the left lumbar region and lies lateral to the left lateral line.

**Pancreas.**—The head of the pancreas lies in the curve of the duodenum and occupies the lowest part of the right half of the epigastric region on a level with the second lumbar vertebra. The neck lies in the transpyloric line, on a level with the fibrocartilage between the first and second lumbar vertebræ. The body lies immediately above the transpyloric line ; the tail lies in the left hypochondriac region, above the transpyloric line and to the left of the left lateral line.

**Spleen.**—The normal spleen is not palpable and never extends anterior to the midaxillary line. It lies obliquely in the left hypochondriac region ; its long axis corresponds to the tenth rib. Its highest point is on a level with the ninth thoracic spine and 1½ in. from the middle line of the back. Its lowest point is on a level with the first lumbar spine and is on the midaxillary line.

**Liver.**—The limits of the liver have been marked out by Birmingham by taking three points : the first point is ½ in. below the right nipple ; the second point is $\frac{1}{2}$ in. below the right tenth rib ; the third point is 1 in. below the left nipple. The three points are joined in the following manner by lines, exhibiting gentle curves conforming to the shape of the organ. The first and third points are joined by a line which has a slightly upward concave curve at its middle part. The second and third points are joined by a line which has a slighly downward convex curve. The first and second points are joined by a line with a slighly lateral convex curve. The *fundus of the gall bladder* comes to the surface of the body behind the anterior end of the ninth right costal cartilage and at the lateral border of the right rectus abdominis.

The **kidneys** are mapped out by two methods : (1) direct, (2) Morris's parallelogram. On the anterolateral wall of the abdomen the upper pole of the kidney is indicated by a point which lies midway between the lower border of the body of the sternum and the transpyloric line, 2 in. lateral to the median line ; the lower pole is indicated by a point which lies midway between the transpyloric and transtubercular lines, 3 in. from the median line ; the hilum lies in the neighbourhood of the transpyloric line, 2 in. from the median line. Taking these three points as guides, a kidney-shaped figure is to be drawn $4\frac{1}{2}$ in. in length and $2\frac{1}{2}$ in. in breadth—two thirds of this figure should occupy medial to the lateral line.

*Morris's parallelogram.*—In this method the surface lines are drawn on the back which mark out a parallelogram within which the kidney is situated. Two vertical lines are drawn from the level of the eleventh thoracic spine to the level of the third lumbar spine—the first line 1 in. lateral to the middle line and the second $3\frac{1}{2}$ in. lateral to the middle line. Two horizontal lines are then drawn joining respectively the superior and inferior ends of the two vertical lines . The hilum corresponds to a point 2 in. lateral to the middle line, on a level with the first lumbar spine.

The *kidney angle* is situated in the scapular line between the lateral border of the sacrospinalis and the twelfth rib. It requires palpation in certain kidney diseases. It also indicates the site where the lower border of the pleura crosses the twelfth rib.

The abdominal portion of the **ureter** is marked on the anterior aspect of the body by a line from the hilum of the kidney to the pubic tubercle ; on the posterior aspect by a line from the hilum to the posterior superior iliac spine.

**Arteries.**—The *abdominal aorta* is indicated by a broad line drawn from a point in the middle line $1\frac{1}{2}$ in. above the transpyloric line to a point $\frac{1}{2}$ in. below and to the left of the umbilicus—if the umbilicus appears to be an unrealiable landmark the point is determined by the fact that the umbilicus is on a level with the highest points of the iliac crests. If a line is drawn from the bifurcation of the abdominal aorta to the midpoint between anterior superior iliac spine and the symphysis pubis—the upper third of this line represents the *common iliac artery* and the lower two thirds, the *external iliac artery*. The *inferior epigastric artery* is indicated by a line drawn from a point midway between the anterior superior iliac spine and the symphysis pubis to the umbilicus. It runs at first inferior and then medial to the abdominal inguinal ring—this relation is important in the operation of hernia; it also forms the lateral boundary of Hesselbach's triangle (p. 428).

## THE BACK

The following table will be found useful in determining the relation of some of the important structures to the spines of the vertebræ.

| Spines of vertebræ. | Origins of spinal nerves. | Other structures. |
|---|---|---|
| 1 C. | 3 C. | Soft palate. |
| 2 C. | 4 C. | Isthmus of fauces. |
| 3 C. | 5 C. | Epiglottis. |
| 4 C. | 6 C. | Vocal folds. |
| 5 C. | 7 C. | Conus elasticus. |
| 6 C. | 8 C. | Commencement of trachea and œsophagus. |
| 7 C. | 1 T. | Apex of lung. |
| 1 T. | 2, 3 T. | Highest part of arch of subclavian artery. |
| 2 T. | 4 T. | Summit of arch of aorta. |
| 3 T. | 5 T. | Sternal angle.<br>Lower limit of superior mediastinum.<br>Bifurcation of trachea.<br>Termination of arch of aorta. |
| 4 T. | 6 T. | Beginning of descending thoracic aorta.<br>Superior limit of heart.<br>Right and left bronchus. |
| 5 T. | 7 T. | Centre of root of lung.<br>Mitral orifice. |
| 6 T. | 8 T. | Tricuspid orifice. |
| 7 T. | 9 T. | Orifice of inferior vena cava.<br>Right arch of diaphragm.<br>Inferior angle of scapula. |
| 8 T. | 10 T. | Fundus of stomach.<br>Left arch of diaphragm.<br>Inferior limit of heart. |
| 9 T. | 11 T. | Upper limit of spleen. |

| Spines of vertebræ. | Origins of spinal nerves. | Other Structures. |
|---|---|---|
| 10 T. | 12 T. | Cardiac orifice and lesser curvature of stomach. |
| | | Upper pole of left kidney. |
| | | Lower border of lung, posteriorly. |
| 11 T. | 1 L. | Lesser curvature of stomach. |
| | | Body of pancreas. |
| | | Upper pole of right kidney. |
| | | Lower limit of pleura at vertebral column. |
| 12 T. | 2 L. | Lower limit of pleura at twelfth rib. |
| | 3 L. | Pyloric portion of stomach and pylorus. |
| | 4 L. | Left flexure of colon. |
| | | Head of pancreas (superior part). |
| | | Kidney angle. |
| 1 L. | 5 L. | Lower end of spleen. |
| | 1 S. | Lower limit of pleura at midaxillary line. |
| | 2 S. | Greater curvature of stomach. |
| | 3 S. | Descending part of duodenum. |
| | 4 S. | Right flexure of colon. |
| | 5 S. | Head of pancreas (inferior part). |
| | 1 C. | Hilum of kidney. |
| | | Portal vein. |
| | | Bile duct. |
| | | Conus medullaris. |
| 2 L. | .... | Commencement of ureter. |
| 3 L. | .... | Lower poles of kidneys. |
| 4 L. | .... | Highest part of iliac crest. |
| | | Umbilicus. |
| | | Bifurcation of aorta. |
| 5 L. | .... | Colic valve. |
| | | Common iliac arteries. |

The *medulla spinalis* extends inferiorly in the adult to the level of the second lumbar spine; in the infant, to the third lumbar spine. The subdural and subarachnoid cavities extend inferiorly as far as the second or third sacral vertebra.

## THE SUPERIOR EXTREMITY

**Bones.**—The different parts of the *scapula* which can be made out easily are the vertebral border, axillary border, inferior angle, and the crest of the spine; the tip of the acromion lies a finger's breadth lateral to and in front of the lateral end of the clavicle; the acromion forms the point of the shoulder, and joins the clavicle forming the *acromial angle* which is medial to and behind the tip of the acromion. The *humerus* is practically clothed by muscles. The head is identified by its movements when the arm is moved. The greater tubercle forms the most lateral bony landmark of the shoulder and projects beyond the acromion. The lesser tubercle may be felt 1 in. lateral to and a little below the tip of the coraciod process. The intertubercular sulcus is indicated by a line 2 in. in length drawn distally along the axis of the humerus from the tip of the acromion. The medial and lateral supracondylar ridges can be felt; the lateral is more prominent. The medial epicondyle is more conspicuous than the lateral. The lateral epicondyle is seen plainly as an eminence during semiflexion of the forearm.

The olecranon is the most prominent part of the *ulna* and can always be felt at the back part of the elbow joint between the two epicondyles. The triangular subcutaneous surface at the back part of the olecranon is felt as the continuation of the dorsal border of the body of the ulna—this border is subcutaneous throughout its whole length. When the hand is pronated the head of the ulna is easily seen on the medial part of the dorsal aspect of the wrist and the styloid process is felt distal but ventral to the head. When the forearm is extended there is a slight dimple immediately below the lateral epicondyle of the humerus—this dimple corresponds with the head of the *radius* which may be felt to rotate if the forearm is alternately pronated and supinated. The proximal half of the body of the radius is felt indistinctly through the muscles but the distal half is rather subcutaneous. The styloid process of the radius is felt lying distal to the lateral aspect of the distal end of the bone and its tip lies ½ in. distal to the tip of the styoloid process of the ulna. If the wrist is flexed the dorsal radial tubercle is felt on the middle of the dorsal surface of the distal end of the radius. On the lateral side of the front of the wrist the tuberosity of the *navicular bone* is felt about the middle of the proximal border of the thenar eminence, and the ridge on the *greater multangular bone* immediately distal to the tuberosity of the navicular. On the medial side of the front of the wrist the *pisiform bone* is easily felt and the haumlus of the *hamate bone* can be felt with great difficulty ½ in. distal to the pisiform. On the dorsum of the wrist the triquetrum can be easily felt and in full flexion of the wrist joint the head of the capitate is felt with difficulty.

The prominences of the knuckles are formed by the heads of the *metacarpal bones*; the head of the third is the most prominent. The bodies of the metacarpals are felt on the dorsum of the hand where they are covered by tendons but in the palm they lie concealed beneath the muscles and tendons. The bases of the metacarpals can be felt with difficulty on the dorsum of the wrist—that of the thumb is prominent dorsally. The styloid process of the base of the third metacarpal may be felt lateral to the middle line of the hand 1½ in. distal to the dorsal radial tubercle. The *phalanges* are easily felt and their heads form the knuckles of the fingers.

**Articulations.**—The *shoulder joint* is deeply situated and can be examined only by pushing up the fingers in the axilla. The *elbow joint* is indicated in front by a line drawn parallel and immediately distal to the crease which is seen in front of the elbow when the forearm is slightly flexed; the humeroradial portion lies about $\frac{3}{4}$ in. distal to the lateral epicondyle; the humeroulnar portion lies about 1 in. distal to the medial epicondyle. The *wrist joint* is indicated by drawing a curved line having its convexity upwards from the styloid process of the radius to that of the ulna—the summit of the curve reaches about 1 in. above the midpoint of a line joinning the two processes. The *transverse carpal ligament* is indicated by two parallel lines; the proximal border extends from the tuberosity of the navicular to the pisiform, and the distal border from the ridge on the greater multangular to the hook of the hamate.

**Muscles.**—The anterosuperior border of the *trapezius* is delineated by drawing a line from a point about $1\frac{1}{4}$ in. lateral to the external occipital protuberance to a point corresponding to the junction of the middle and lateral thirds of the clavicle. The *deltoideus* gives the rounded outline of the shoulder. The *biceps brachii* forms a long prominence in front of the arm and its tendon can be easily felt at the bend of the elbow. In a fairly muscular subject three muscular elevations can be recognised on the front aspect of the elbow. The one in the middle corresponds to the tendon of the biceps brachii; that on the lateral side corresponds to the brachioradialis and the common mass of extensor muscles of the forearm attached to the lateral epicondyle of the humerus; and that on the medial side corresponds to the position of the pronator teres and the common mass of flexor muscles of the forearm attached to the medial epicondyle the humerus. The tendon of the *triceps brachii* can be felt as it passes down the distal portion of the posterior aspect of the arm to be inserted into the olecranon. The tendons in the region of the wrist, both flexors and extensors, can be felt if they are made prominent by causing their muscles to contract.

In the middle of the palm is a triangular hollow depression with its apex directed upwards towards the wrist. On the ulnar side of the palm is a rounded eminence, called the *hypothenar eminence,* produced by the short muscles of the little finger; on the radial side is another elevation, called the *thenar eminence,* formed by the short muscles of the thumb.

**Arteries.**—To indicate the *axillary artery* the arm should be abducted to a right angle and then a line is to be drawn from the middle of the clavicle to the point where the tendon of the pectoralis major crosses the prominence of the coracobrachialis. The *brachial artery* is indicated by a line drawn from the point of the termination of the axillary artery (the point is noted above) to a point about $\frac{1}{2}$ in. distal to the middle of the bend of the elbow. The *radial artery* is indicated by a line drawn from the point of bifurcation of the brachial artery to a point just medial to the tip of the styloid process of the radius and thence the line is continued round the radial side of the wrist to the proximal extremity of the space between the first and second metacarpal bones. The *ulnar artery* is indicated by two lines: the first line is drawn from the medial epicondyle of the humerus to a point just lateral to the pisiform bone; the second line is drawn from the point of bifurcation of the brachial artery to the junction of the proximal and middle thirds of first line; the second line indicates the proximal third of artery; the distal two thirds of the first line indicate the distal two-thirds of the artery. The *superficial volar arch* is indicated by a curved line with its convexity directed distally from the radial side of the pisiform bone to the distal portion of the medial border of the thenar eminence; the curved line stretches across the palm and the summit of its convexity is at a point in the middle line of the palm at the level of the distal border of the outstretched thumb. The *deep volar arch* lies transversely midway between the distal border of the transverse carpal ligament and the superficial volar arch.

**Veins.**—The arrangement of the superficial veins at the elbow is of great importance because a vein in this region is selected for intravenous infusion. Naturally the suitable vein for this work is selected and this is the median cubital vein. When the median cubital vein is absent the median antibrachial vein bifurcates below the middle of the elbow into (1) the *median basilic vein* which runs proximally and medially and joins the basilic vein almost immediately above the elbow, and (2) the *median cephalic vein* which runs proximally and laterally and joins the cephalic vein almost immediately above the elbow. Above the elbow, the basilic vein runs along the medial border of the biceps brachii while the cephalic vein runs along the lateral border of the biceps brachii. These veins can be indicated on the surface by following the directions given above.

**Nerves.**—The *axillary nerve* is indicated by a transverse line across a point about $\frac{3}{4}$ in. above the midpoint between the tip of the acromion and the lower limit of the insertion of the deltoideus. In the arm the line of the *median nerve* is the same as that of the brachial artery but the line should conform to the following relations viz., the nerve lies lateral to the artery at the upper part of the arm and medial to the artery above the bend of the elbow. In the forearm the median nerve is indicated by a line drawn from a point midway between the medial epicondyle and the tendon of the biceps brachii to the middle of the front of the wrist. In the arm the line of the *ulnar nerve* is the same as that of the brachial artery but the line should conform to the following relations viz., the nerve lies medial to the artery in the upper half of the arm; at the midle of the arm it separates from the artery to pass to the back of the medial epicondyle where it can be easily felt. In the forearm the ulnar nerve is indicated by a line from the medial epicondyle to the lateral side of the pisiform bone. The *radial nerve* is indicated by a line drawn from the inferior margin of the posterior axillary fold to the lateral aspect of the arm at the junction of its middle and lower thirds; thence the line is continued vertically to the front of the lateral epicondyle. The *superficial radial nerve* is indicated by a line drawn from the front of the lateral epicondyle to the junction of the middle and distal thirds of the radius; it then winds obliquely dorsally to run distally to the dorsum of the base of the first metacarpal bone.

## THE INFERIOR EXTREMITY

**Bones.**—Most of the bony points of the *pelvis* have been described. The tuberosity of the ischium is overlapped by the inferior margin of the glutaeus maximus and is easily felt if the hip joint is flexed as it then becomes uncovered by the muscle. The outline of the pubic arch can be palpated forming the boundary of the perineal space. The upper margin of the greater sciatic notch lies opposite the third sacral spine. The greater trochanter of the *femur* is the most lateral bony landmark of the hip and lies a hand's breadth below the tubercle on the crest of the ilium. The lesser trochanter is felt by deep palpation proximal to the lateral end of the gluteal fold after the hip is rotated medially. The medial and lateral condyles of the femur are subcutaneous; these as also their epicondyles are palpable. The adductor tubercle is felt at the proximal and posterior part of the medial condyle of the femur; it indicates the level of the epiphyseal cartilage. When the knee is flexed the upper part of the patellar surface of the femur can be felt.

For clinical purposes certain lines are drawn to ascertain the anatomical interrelationships of bony landmarks about the region of the hip. These are: (1) *Nelaton's line* is drawn from the anterior superior iliac spine to the most prominent part of the ischial tuberosity—this line passes over the highest part of the greater trochanter and also crosses the centre of the acetabulum. (2) *M'curdy's line* is drawn laterally from the pubic tubercle at right angles to the middle line of the body—this line passes over the highest part of the greater trochanter, since the pubic tubercle is on a level with that landmark. (3) *Bryant's triangle* is thus mapped out, the subject lying flat on his back: (a) a vertical line is drawn from the anterior superior iliac spine over the lateral aspect of the region of the hip on to the table the subject is lying; (b) a vertical line is drawn from the highest part of the greater trochanter to meet the first line at right angles; (c) a line is drawn from the anterior superior spine to the top of the trochanter and thus the triangle is completed (4) *Chiene's lines.*—These are two lines—one joins the two anterior superior iliac spines; the other joins the tops of the two great trochanters. Normally they are parallel. The anterior surface of the *patella* is subcutaneous and can be easily felt. The *tibia* is subcutaneous to a large extent—its medial and lateral condyles, tuberosity, anterior crest, medial surface of the body, and medial malleolous can all be palpated. The head of the *fibula* can be felt on the posterolateral aspect of the knee at the level of the tuberosity of the tibia. The lower portion of the body of the fibula and the lateral malleolus can be easily palpated. The tip of the lateral malleolus lies further distally and further posteriorly than the tip of the medial malleolus.

Along the lateral margin of the *foot* can be felt: the subcutaneous lateral surface of the calcaneus; the cuboid in front of it;

and the tuberosity at the base of the fifth metatarsal bone. Along the medial margin of the foot can be felt : the medial process of the calcaneal tuberosity ; the medial margin of the sustentaculum tali ; the tuberosity of the navicular bone ; the medial surface of the first cuneiform bone ; and the first metatarsal bone. The dorsal surfaces of the *metatarsal bones* are felt rather indistinctly as they are covered by the extensor tendons ; their plantar surfaces lie concealed by muscles. The *phalanges* are easily palpated.

**Joints.**—The *hip joint* is deeply seated and can not be palpated but the head of the femur can be felt by rotating the limb medialwards and lateralwards and placing the thumb of one hand in front in the hollow below the inguinal ligament and the fingers behind the greater trochanter. The *knee joint* is represented by a triangular gap bounded by the upper border of medial condyle of the tibia, medial border of the patella and the medial condyle of the femur, after the joint is semiflexed. The *ankle joint* is represented by the hollows between the extensor tendons in front of and behind the malleoli.

**Muscles.**—The prominence of the nates is caused by the *glutaeus maximus* and the transverse groove, called the *gluteal sulcus*, corresponds approximately to the lower border of this muscle. The *natal cleft* extends as a deep fissure separating the nates below in the middle line. The *iliotibial tract* is a conspicuous band which, in the region of the knee, lies parallel with and a finger's breadth in front of the tendon of the biceps femoris. The furrow which demarcates the front of the thigh from the abdomen corresponds to the inguinal ligament which can be felt as a tense band stretching from the anterior superior iliac spine to the pubic tubercle. In front of the thigh and just below the inguinal ligament which forms its base is a triangular depression which corresponds to the *femoral triangle*. In this triangle is the *fossa ovalis* which is indicated by an elliptical figure 1½ in. long, 1 in. broad with its long axis vertical and its centre lies about 1½ in. below and lateral to the pubic tubercle ; the *femoral ring* lies deep to the inguinal ligament and is about ½ in. lateral to the pubic tubercle. The *adductor canal* occupies the middle third of the thigh.

Above the knee the tendons of the biceps femoris, semimembranosus and semitendinosus forming the upper boundaries of the upper part of the *popliteal fossa* can be easily palpated ; below the knee the prominence caused by the two heads of the gastrocnemius forming the lower boundaries of the fossa, is distinctly seen. The tendons in the region of ankle can be distinguished when their muscles are brought to action.

**Arteries.**—The *femoral artery* is mapped out with the thigh slightly flexed and rotated laterally by drawing a line from the midpoint of a line between the anterior superior iliac spine and the symphysis pubis to the adductor tubercle of the femur ; the proximal two thirds of this line represent the femoral artery—its proximal third representing the artery in the femoral triangle, and the middle third, the artery in the adductor canal. The *profunda femoris* arises from the femoral about 1½ in. below the inguinal ligament. The *popliteal artery* is indicated by drawing a line medial to the proximal angle of the popliteal fossa (which corresponds to the point where the tendons of the biceps and semimembranosus and semitendinosus diverge) to a point midway between the condyles of the femur in the middle of the popliteal fossa ; thence the line is continued vertically distalwards to the level of the distal part of the tuberosity of the tibia.

The *anterior tibial artery* is indicated by a line drawn from the medial side of the head of the fibula to a point on the front of the ankle midway between the two malleoli—the artery begins about 1¼ in. below the head of the fibula. The *dorsalis pedis artery* is mapped out by a line drawn from a point on the front of the ankle midway between the two malleoli to the posterior end of the first intermetatarsal space. The *posterior tibial artery* is indicated by a line drawn from the point of bifurcation of the popliteal artery to a point midway between the medial malleolus and the tendo calcaneus. The *peroneal artery* begins about 3 in. below the level of the knee joint and descends along the fibula. The *medial plantar artery* begins from the point of bifurcation of the posterior tibial and extends to the middle of the ball of the great toe. The *lateral plantar atrery* extends to a point about ½ in. medial to the tuberosity of the fifth metatarsal bone. The *plantar arch* is mapped out by drawing a curved line with its convexity directed towards the toes across the sole from the medial side of the base of the fifth metatarsal bone to the proximal end of the first intermetatarsal space.

**Veins.**—The line of the *femoral vein* is like that of the femoral artery but the line should conform to the relations of the artery and the vein. The line of the *popliteal vein* is similar to that of the popliteal artery. The *great sapphenous vein* is indicated by drawing a line from the front of the medial malleolus, along the medial aspects of the leg and thigh, to the fossa ovalis. The *small saphenous vein* commences on the lateral side of the foot passes behind the lateral malleolus and then straight up the back of the leg to the middle of the popliteal fossa.

**Nerves.**—The *femoral nerve* is indicated by a line drawn from a point 1 in. lateral to the midinguinal point distalwards to the extent of about 1 in. The course of the *sciatic nerve* corresponds to the proximal half of a line drawn from a point midway between the top of the greater trochanter and the outer border of the ischial tuberosity to the proximal angle of the popliteal fossa. The *tibial nerve* is represented by a line drawn from the point of bifurcation of the sciatic nerve to a point midway between the the medial malleolus and the tendo calcaneus. The *common peroneal nerve* is indicated by a line drawn from the point of bifurcation of the sciatic nerve and then following the tendon of the biceps femoris and ultimately reaching the neck of the fibula. The *deep peroneal nerve* is indicated by a line drawn from the point of bifurcation of the common peroneal nerve to a point on the front of the ankle midway between the two malleoli.

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